IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

SAMSUNG ELECTRONICS CO., LTD.,	)	
	)	
Plaintiff,	)	
	)	
v.	)	C.A. No. ______________
	)	
PETTERS GROUP WORLDWIDE, LLC, POLAROID CORPORATION, and WESTINGHOUSE DIGITAL ELECTRONICS, LLC,	)	**JURY TRIAL DEMANDED**
	)	
Defendants.	)	

<u>COMPLAINT FOR PATENT INFRINGEMENT</u>

Plaintiff Samsung Electronics Co., Ltd. ("Samsung") alleges as follows:

<u>THE PARTIES</u>

1. Plaintiff Samsung is a corporation of Korea, having its principal place of business in Seoul, Korea.

2. On information and belief, Defendant Petters Group Worldwide, LLC ("Petters Group") is a Delaware limited liability company, having its principal place of business at 4400 Baker Road, Minnetonka, Minnesota 55343, and doing business in this jurisdiction and elsewhere in the United States.

3. On information and belief, Defendant Polaroid Corporation ("Polaroid") is a Delaware corporation, having its principal place of business at 1265 Main Street, Building W-3, Waltham, Massachusetts 02451, and doing business in this jurisdiction and elsewhere in the United States.

4. On information and belief, Defendant Westinghouse Digital Electronics, LLC ("Westinghouse") is a California limited liability company, having its principal place of

business at 12150 Mora Drive, Santa Fe Springs, California 90670, and doing business in this jurisdiction and elsewhere in the United States.

JURISDICTION

5. This Court has subject matter jurisdiction over the action pursuant to 28 U.S.C. §§ 1331 and 1338(a) because this action arises under the patent laws of the United States (Title 35 of the United States Code).

6. On information and belief, Defendants Petters Group, Polaroid (collectively "Polaroid"), and Westinghouse (all together "Defendants") do business in this District and have committed the acts of infringement complained of herein in this District and elsewhere. Personal jurisdiction over Defendants is proper in this Court because their contacts with this District are sufficient to render Defendants amenable to personal jurisdiction in this District.

VENUE

7. Venue is appropriate in this District pursuant to 28 U.S.C. §§ 1391(b), (c) and § 1400(b).

THE SAMSUNG PATENTS

8. United States Patent No. 6,184,938 ("the '938 patent") (Exhibit ("Exh.") 1), entitled "Ghost Cancellation Reference Signal With Bessel Chirps & PN Sequences, & TV Receiver Using Such Signal," was issued on February 6, 2001, based on an application no. 09/246,182 filed on February 4, 1999. Samsung is the sole owner of the entire right, title, and interest in the '938 patent.

9. United States Patent No. 6,480,239 ("the '239 patent") (Exh. 2), entitled "Ghost Cancellation Reference Signal With Bessel Chirps And PN Sequences, And TV Receiver Using Such Signal," was issued on November 12, 2002, based on an application no. 09/575,259

filed on May 19, 2000. Samsung is the sole owner of the entire right, title, and interest in the '239 patent.

10. United States Patent No. 6,937,292 ("the '292 patent") (Exh. 3), entitled "Ghost Cancellation Reference Signal With Bessel Chirps And PN Sequences, And TV Receiver Using Such Signal," was issued on August 30, 2005, based on an application no. 08/158,299 filed on November 29, 1993. Samsung is the sole owner of the entire right, title, and interest in the '292 patent.

11. United States Patent No. 6,104,436 ("the '436 patent") (Exh. 4), entitled "Method And Apparatus For Displaying Subchannel Information In A Digital TV Receiver," was issued on August 15, 2000, based on an application no. 09/033,006 filed on March 2, 1998. Samsung is the sole owner of the entire right, title, and interest in the '436 patent.

THE ATSC DIGITAL TELEVISION SYSTEM

12. Television can be transmitted by different methods, such as by cable, satellite, or terrestrial broadcast. Terrestrial broadcast television is television that is transmitted on radio frequency channels through the air from broadcast antennas to television antennas.

13. Historically, terrestrial broadcast television in the United States has been transmitted by an analog system developed by the National Television System Committee, commonly known as NTSC. In 1995, the Federal Communications Commission (the "FCC") adopted a digital television system developed by the Advanced Television Systems Committee, Inc., commonly known as ATSC, for digital terrestrial television broadcasts. Currently, many broadcasters simultaneously broadcast television terrestrially on two radio frequency channels, an NTSC analog television signal on a first radio frequency channel and an ATSC digital television signal on a second radio frequency channel. The FCC has mandated that in February 2009, the ATSC digital television system will completely replace the NTSC analog system, and

all terrestrially broadcast television will be broadcast according to the ATSC digital television system.

14. The ATSC digital television system is described in the following documents (available at http://www.atsc/org): ATSC Document A/53: "ATSC Digital Television Standard Part 1-6," 2007 (hereafter "A/53"); ATSC Document A/65: Program and System Information Protocol for Terrestrial Broadcast and Cable, Revision C, with Amendment No. 1 (hereafter "A/65"); ATSC Document A/54: Recommended Practice: Guide to the Use of the ATSC Digital Television Standard, including Corrigendum No. 1 (hereafter "A/54"); ATSC Document A/74: ATSC Recommended Practice: Receiver Performance Guidelines with Corrigendum No. 1, (hereafter "A/74"); and ATSC Document A/69: ATSC Recommended Practice: Program and System Information Protocol Implementation Guidelines for Broadcasters (hereafter "A/69").

ATSC AND SAMSUNG'S PATENTS '938, '239, '292 AND '436

15. Samsung's '938, '239, '292 and '436 patents are necessarily infringed when using the ATSC digital television system. For example, any receiver which is capable of receiving digital ATSC television signals infringes Samsung's '938, '239, '292 and '436 patents.

DEFENDANTS' PRODUCTS AT ISSUE

16. On information and belief, Defendants make, use, sell, offer to sell and/or import at least one of the following: televisions, including LCD televisions, DVD/television combinations, plasma televisions and projection screen televisions; television tuners, including tuner cards; set-top boxes capable of receiving terrestrial broadcast television; and video recorders with tuners, including DVD recorders and digital video recorders ("DVR")/personal video recorders ("PVR") ("DTV Products"). Each of these DTV Products is capable of receiving digital ATSC television signals.

17. On information and belief, Defendants make, use, sell, offer to sell, import and/or place into established distribution channels DTV Products in the United States (including in this District) that are capable of receiving digital ATSC television signals.

18. Defendants have had an opportunity to license the patents in suit by either licensing one or more such patents directly from Plaintiff or, in the alternative, by taking a license from MPEG LA, L.L.C. ("MPEG LA"), which offers a non-discriminatory patent portfolio license under many patents essential to the ATSC digital television system, including all patents in suit.

19. MPEG LA is a company that offers a license for patents from many companies, which patents are essential to the ATSC digital television system, including the patents in suit. This license is offered on a nondiscriminatory basis to any one who requests one. MPEG LA is a non-exclusive licensee of each of the patents in suit as well as numerous other patents essential to the ATSC digital television system. MPEG LA's ATSC patent licensing program is modeled after another MPEG LA patent licensing program for the MPEG-2 video compression standard. MPEG LA began its MPEG-2 patent licensing program after the United States Department of Justice reviewed the circumstances surrounding the formation of MPEG LA's MPEG-2 patent licensing program and issued a favorable Business Review Letter in June 1997.

20. Samsung is committed to license the patents in suit on reasonable terms. As an alternative, Defendants, and indeed any potential licensee, can get a license from MPEG LA as a convenience to the licensee. The MPEG LA license adds an alternative choice to the marketplace, in addition to, not instead of, bilateral licenses with licensors, including Samsung.

21. Competitors of Defendants, such as Funai Corporation, Inc. and Funai Electric Co. have executed the MPEG LA license which Defendants have declined to execute.

22. Notwithstanding the fact Defendants were aware that their products used patents owned by Samsung, Defendants have refused to enter into any license with Samsung.

FIRST CAUSE OF ACTION

(INFRINGEMENT OF THE '938, '239, '292 AND '436 PATENTS AGAINST DEFENDANT POLAROID)

23. Samsung incorporates by reference the allegations set forth in paragraphs 1 through 22 of this Complaint as though set forth in full herein.

24. On information and belief, Polaroid has directly infringed, contributorily infringed, and/or has induced others to infringe, the '938, '239, '292 and '436 patents by making, importing, using, offering to sell, and/or selling within the United States various DTV Products.

25. On information and belief, Polaroid continues to infringe, contributorily infringes, and/or induces others to infringe the '938, '239, '292 and '436 patents.

26. On information and belief, Polaroid's infringement has been willful and with full knowledge of the '938, '239, '292 and '436 patents.

27. Samsung has been and will continue to be damaged and irreparably harmed by Polaroid's infringement, which will continue unless Polaroid is enjoined by this Court.

SECOND CAUSE OF ACTION

(INFRINGEMENT OF THE '938, '239, '292 AND '436 PATENTS AGAINST DEFENDANT WESTINGHOUSE)

28. Samsung incorporates by reference the allegations set forth in paragraphs 1 through 22 of this Complaint as though set forth in full herein.

29. On information and belief, Westinghouse has directly infringed, contributorily infringed, and/or has induced others to infringe, the '938, '239, '292 and '436 patents by making, importing, using, offering to sell, and/or selling within the United States various DTV Products.

30. On information and belief, Westinghouse continues to infringe, contributorily infringes, and/or induces others to infringe the '938, '239, '292 and '436 patents.

31. On information and belief, Westinghouse's infringement has been willful and with full knowledge of the '938, '239, '292 and '436 patents.

32. Samsung has been and will continue to be damaged and irreparably harmed by Westinghouse's infringement, which will continue unless Westinghouse is enjoined by this Court.

WHEREFORE, Plaintiff demands judgment as follows:

1. Adjudging, finding, and declaring that Defendants are infringing the patents in suit.

2. Permanently enjoining Defendants, their officers, agents, servants, employees, and attorneys, and those persons in active concert or participation with them, from infringing the patents in suit, as provided by 35 U.S.C. § 283.

3. Awarding the respective Plaintiff an accounting and damages against Defendants in a sum to be determined at trial, together with interest and costs as fixed by the Court; all of these damages to be enhanced in amount up to treble the amount of compensatory damages, as provided by 35 U.S.C. § 284.

4. Awarding Plaintiff their reasonable attorneys' fees, costs, and disbursements in this action pursuant to 35 U.S.C. § 285.

5. Granting Plaintiff such other and further relief as is just and proper.

JURY DEMAND

Plaintiff hereby demands a trial by jury of all issues that may so be tried.

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Dated: June 10, 2008
868430 / 33215

EXHIBIT 1

US006184938B1

(12) **United States Patent**
Patel et al.

(10) **Patent No.: US 6,184,938 B1**
(45) **Date of Patent: Feb. 6, 2001**

(54) **GHOST CANCELLATION REFERENCE SIGNAL WITH BESSEL CHIRPS & PN SEQUENCES, & TV RECEIVER USING SUCH SIGNAL**

(75) Inventors: **Chandrakant Bhailalbhai Patel**, Hopewell, NJ (US); **Jian Yang**, Bensalem, PA (US)

(73) Assignee: **Samsung Electronics Co., Ltd.** (KR)

(*) Notice: Under 35 U.S.C. 154(b), the term of this patent shall be extended for 0 days.

(21) Appl. No.: **09/246,182**

(22) Filed: **Feb. 4, 1999**

Related U.S. Application Data

(60) Division of application No. 08/158,299, filed on Nov. 29, 1993, which is a continuation-in-part of application No. 07/872,077, filed on Apr. 22, 1992, now abandoned, and a continuation-in-part of application No. 07/984,488, filed on Dec. 2, 1992, now abandoned.

(51) **Int. Cl.**[7] **H04N 5/21**
(52) **U.S. Cl.** **348/614**
(58) **Field of Search** 348/614, 608; H04N 5/21

(56) **References Cited**

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3-293870	12/1991	(JP)	H04N/5/21

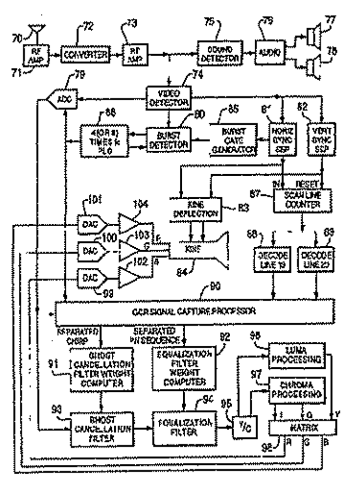
Primary Examiner—Michael H. Lee
(74) *Attorney, Agent, or Firm*—Arnold White & Durkee

(57) **ABSTRACT**

Composite ghost cancellation reference (GCR) signals that make available both a chirp and a PN sequence during the same vertical-blanking-interval (VBI) scan line in each successive field facilitate more rapid and efficient calculations of ghost cancellation and of equalization, on a continuing basis. A television receiver for use with such composite GCR signals includes circuitry for separating the chirp and PN sequence portions of the GCR signals from the remainder of the composite video signal, a ghost cancellation filter and an equalization filter connected in cascade to respond to the composite video signal and provided each with adjustable filtering weights, and a computer. Random-access memory addressed during writing snatches the vertical-blanking-interval scan lines selected to include GCR signals. Sets of four successive ones of the selected scan lines are then additively and subtractively combined to separate the chirp portions of the GCR signals from a remainder of the composite video signal.

The sets of selected scan lines are additively and subtractively combined in another way to separate the PN sequence portions of the GCR signals form a remainder of the composite video signal. The computer responds to the separated chirp portions of the GCR signals to calculate a discrete Fourier transform (DFT) therefrom. The computer proceeds from that DFT to determine the adjustable filtering weights of the ghost cancellation filter. The computer thereafter responds to the separated PN sequences to determine the adjustable filtering weights of the equalization filter.

103 Claims, 6 Drawing Sheets



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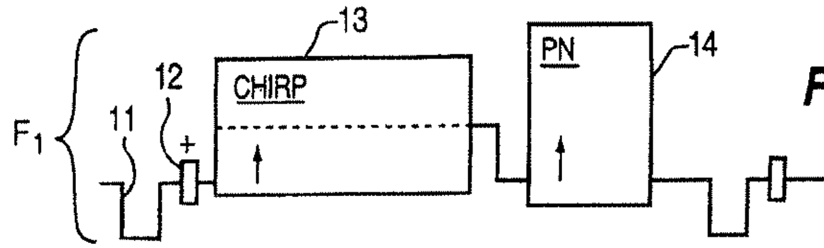


Fig. 1A

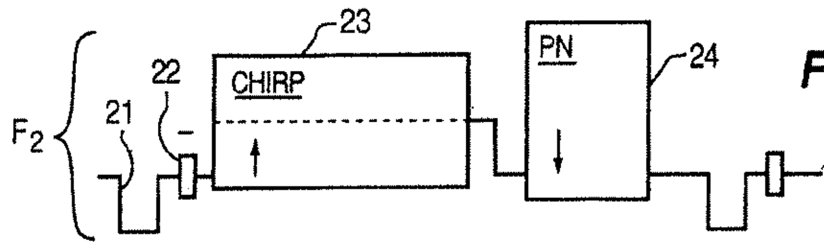


Fig. 1B

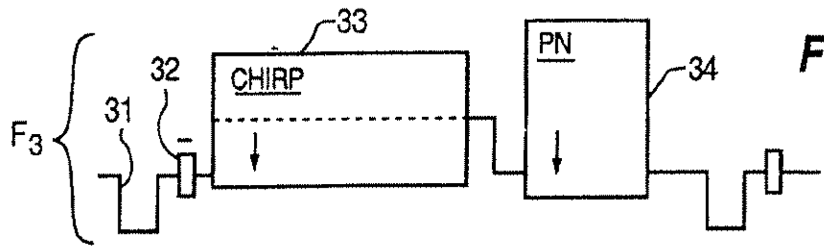


Fig. 1C

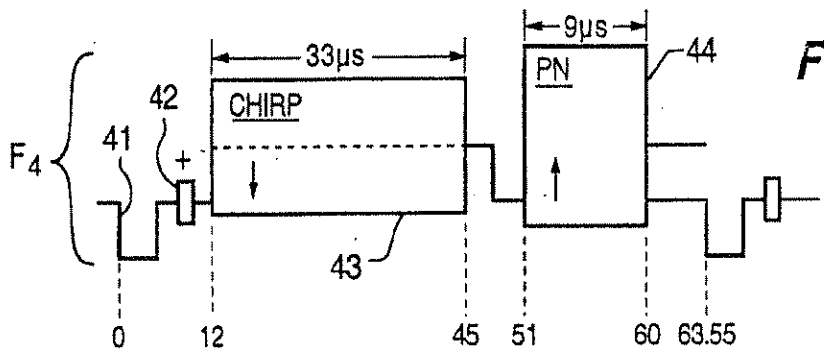


Fig. 1D

Fig. 2

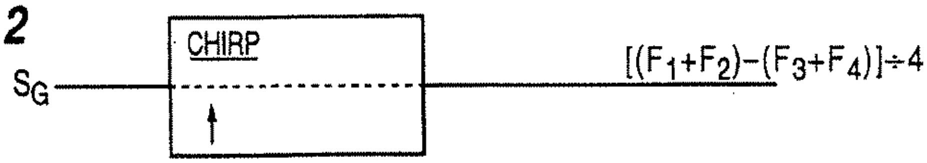
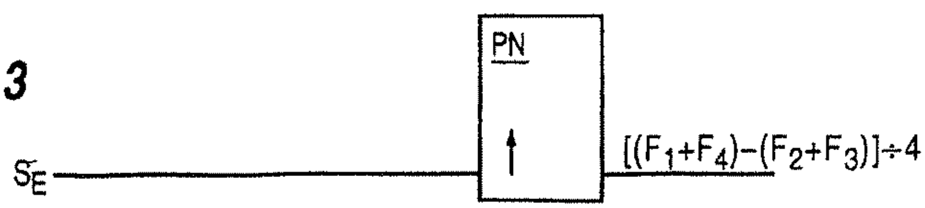
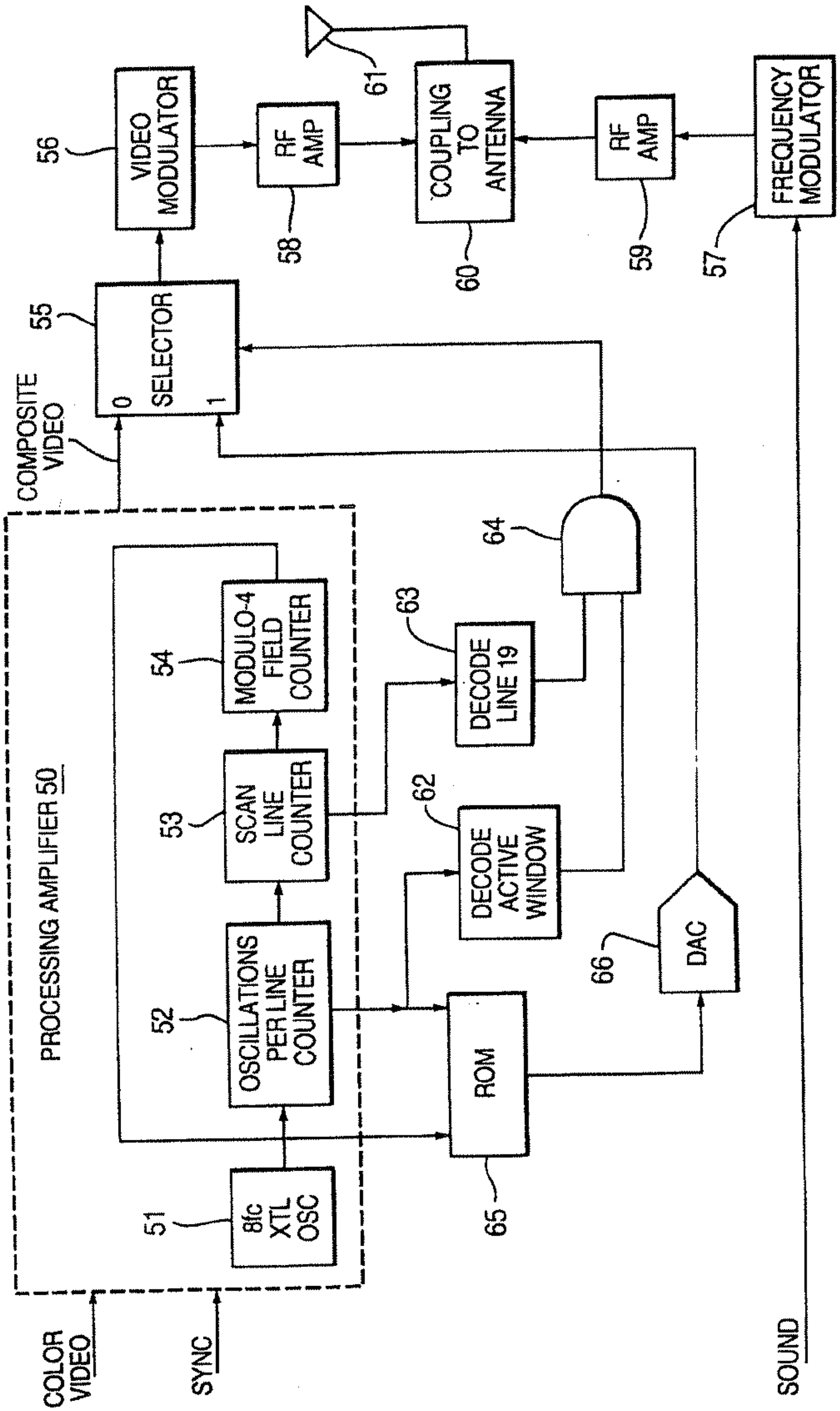


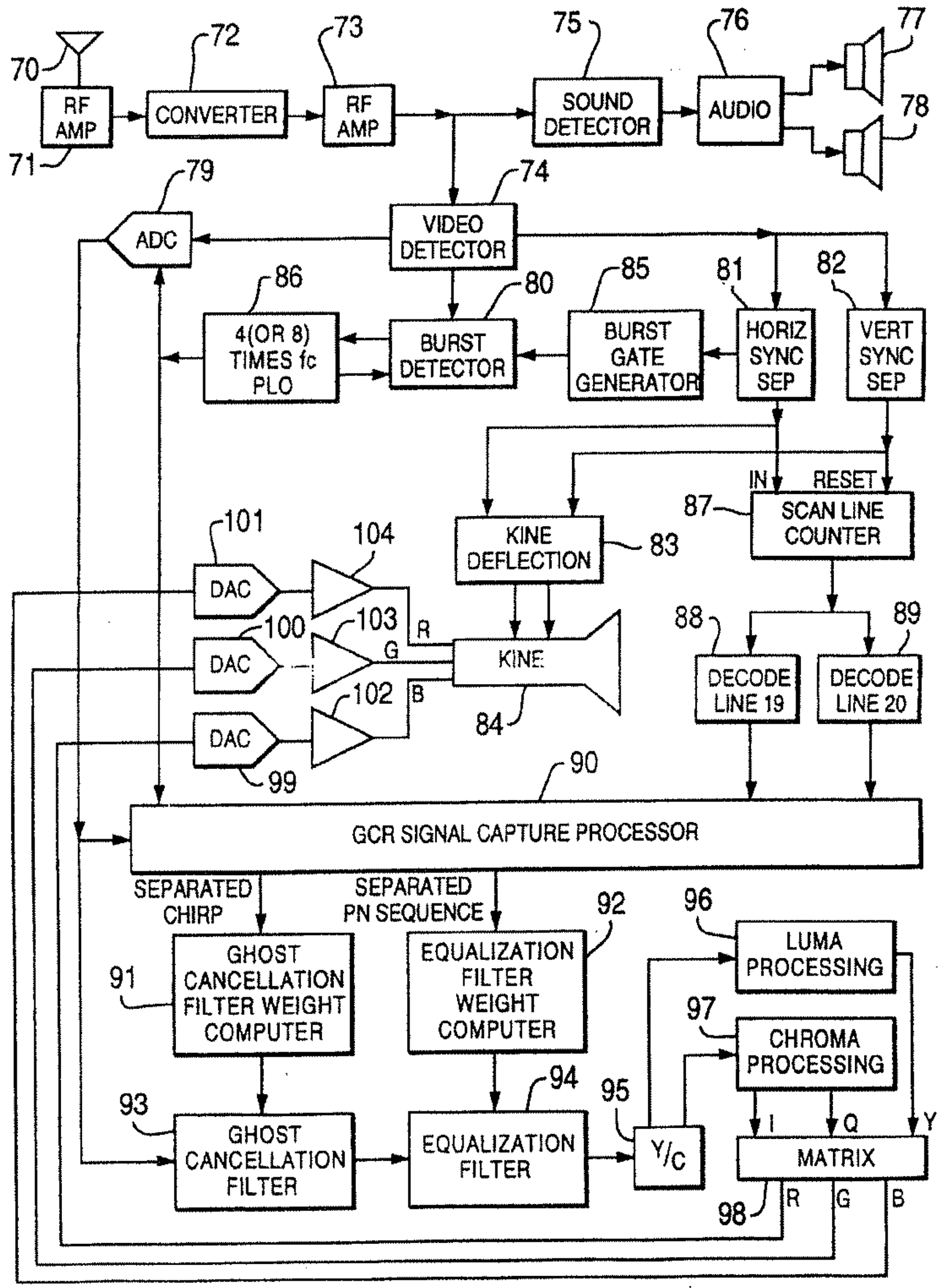
Fig. 3





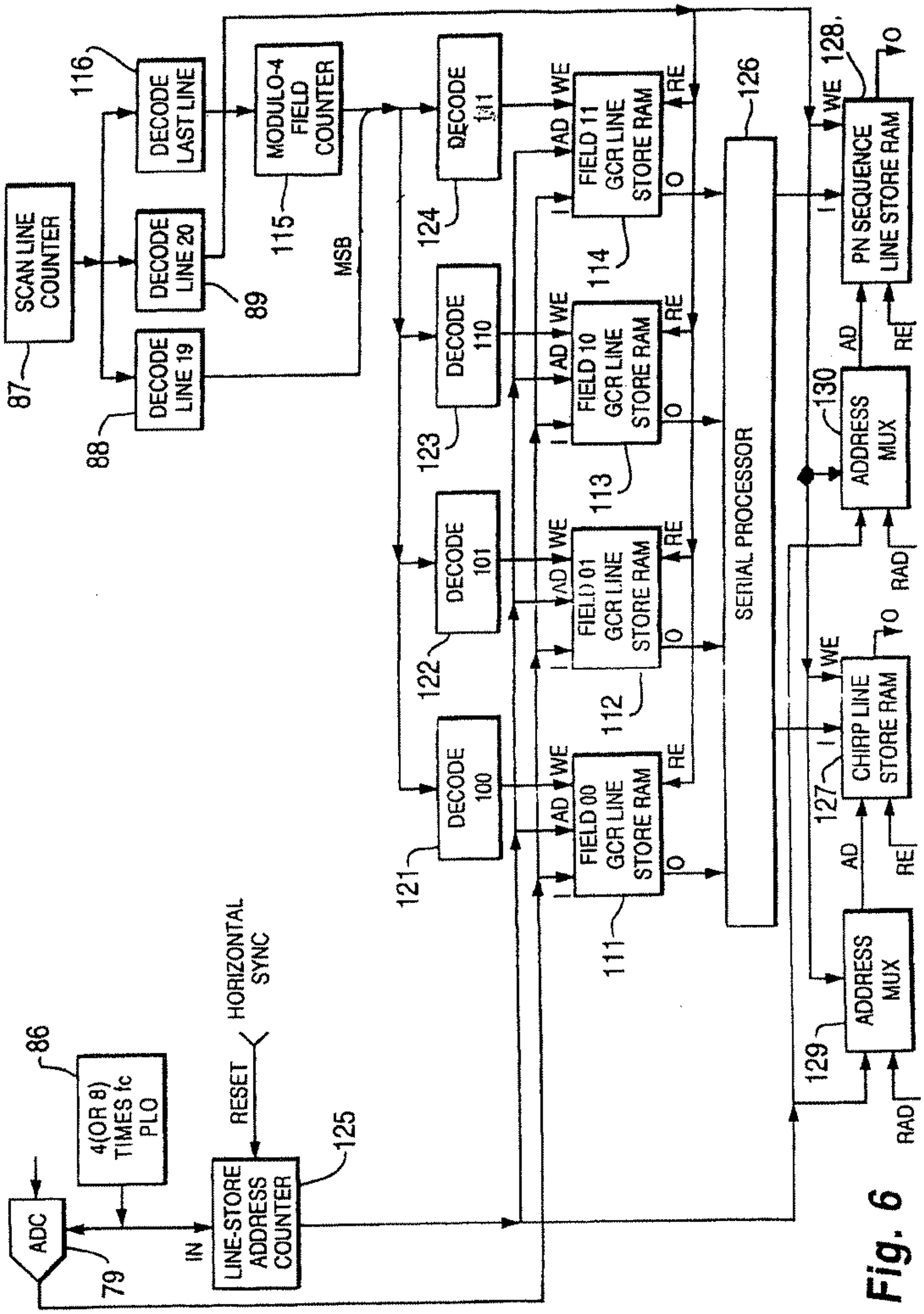
VIDEO MODULATOR
56
RF AMP
58
61
COUPLING TO ANTENNA
60
RF AMP
59
FREQUENCY MODULATOR
57
SELECTOR
55
0
1
COMPOSITE VIDEO
PROCESSING AMPLIFIER 50
MODULO-4 FIELD COUNTER
54
SCAN LINE COUNTER
53
OSCILLATIONS PER LINE COUNTER
52
8fc XTL OSC
51
DECODE LINE 19
63
DECODE ACTIVE WINDOW
62
64
DAC
66
ROM
65
COLOR VIDEO
SYNC
SOUND

Fig. 4



70
71
RF AMP
72
CONVERTER
73
RF AMP
75
SOUND DETECTOR
76
AUDIO
77
78
79
ADC
74
VIDEO DETECTOR
86
4(OR 8) TIMES fc PLO
80
BURST DETECTOR
85
BURST GATE GENERATOR
81
HORIZ SYNC SEP
82
VERT SYNC SEP
IN
RESET
87
SCAN LINE COUNTER
KINE DEFLECTION
83
101
DAC
104
100
DAC
103
102
DAC
99
R
G
B
KINE
84
88
DECODE LINE 19
89
DECODE LINE 20
90
GCR SIGNAL CAPTURE PROCESSOR
SEPARATED CHIRP
SEPARATED PN SEQUENCE
91
GHOST CANCELLATION FILTER WEIGHT COMPUTER
92
EQUALIZATION FILTER WEIGHT COMPUTER
96
LUMA PROCESSING
97
CHROMA PROCESSING
93
GHOST CANCELLATION FILTER
94
EQUALIZATION FILTER
95
Y/C
I
Q
Y
MATRIX
98
R
G
B

Fig. 5


SCAN LINE COUNTER
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DECODE LAST LINE
116
DECODE LINE 20
89
DECODE LINE 19
88
MODULO-4 FIELD COUNTER
115
MSB
DECODE 11
124
DECODE 110
123
DECODE 101
122
DECODE 100
121
FIELD 11 GCR LINE STORE RAM
114
FIELD 10 GCR LINE STORE RAM
113
FIELD 01 GCR LINE STORE RAM
112
FIELD 00 GCR LINE STORE RAM
111
AD
WE
RE
I
O
SERIAL PROCESSOR
126
PN SEQUENCE LINE STORE RAM
128
ADDRESS MUX
130
CHIRP LINE STORE RAM
127
ADDRESS MUX
129
RAD
ADC
79
4(OR 8) TIMES fc PLO
86
HORIZONTAL SYNC
RESET
IN
LINE-STORE ADDRESS COUNTER
125

Fig. 6

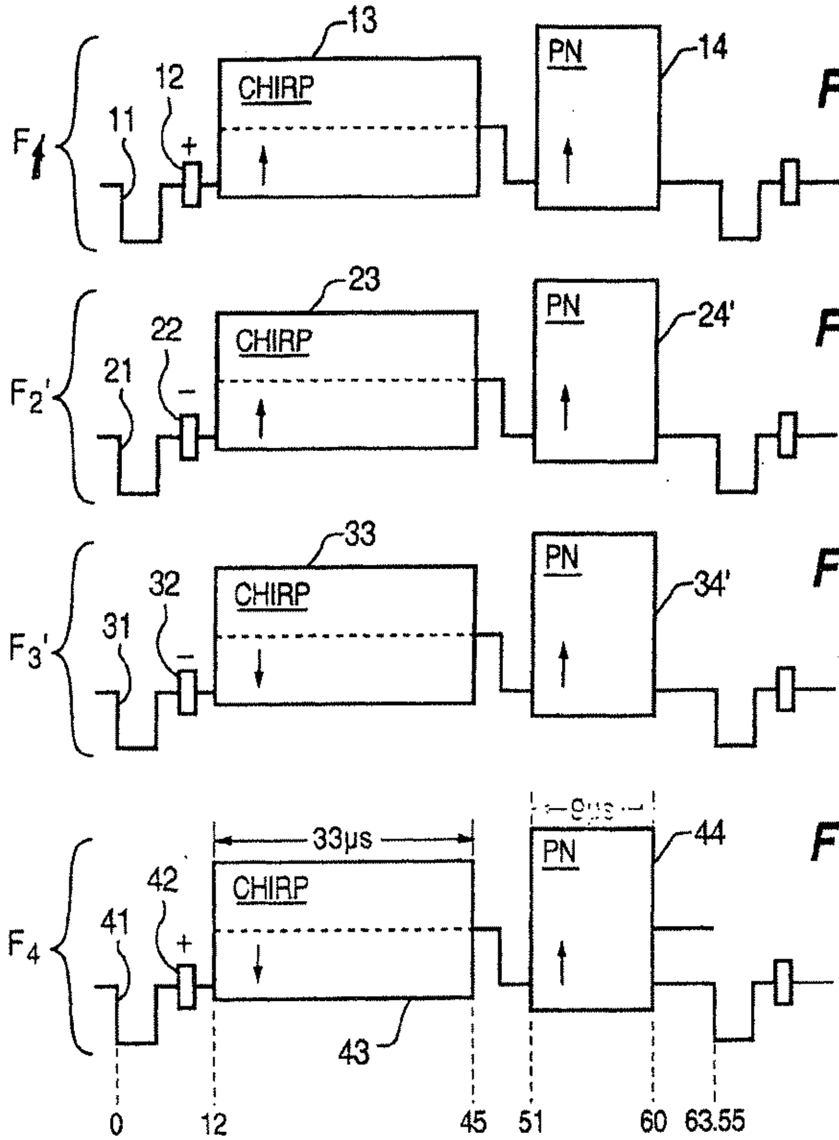


Fig. 7A

Fig. 7B

Fig. 7C

Fig. 7D

Fig. 8

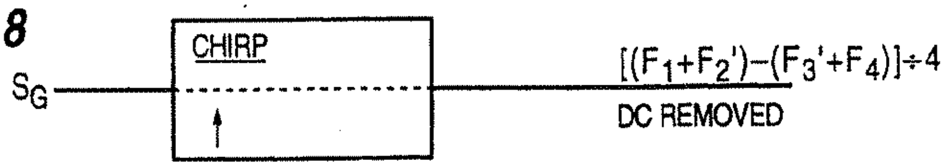
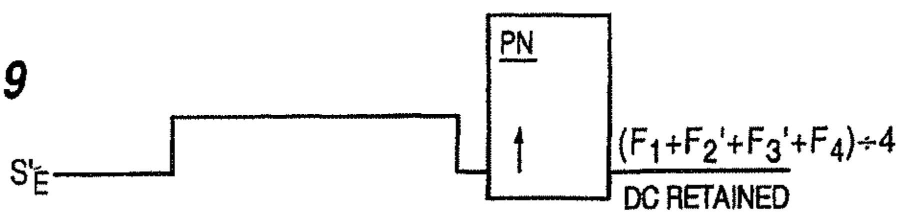


Fig. 9



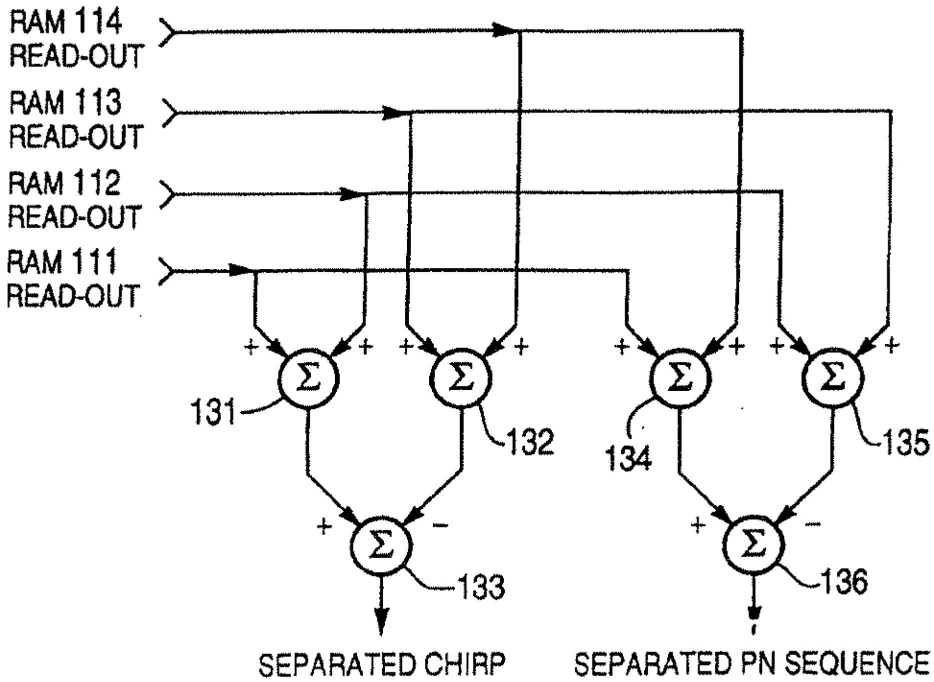

RAM 114
READ-OUT
RAM 113
READ-OUT
RAM 112
READ-OUT
RAM 111
READ-OUT
131
132
133
134
135
136
SEPARATED CHIRP
SEPARATED PN SEQUENCE

Fig. 10

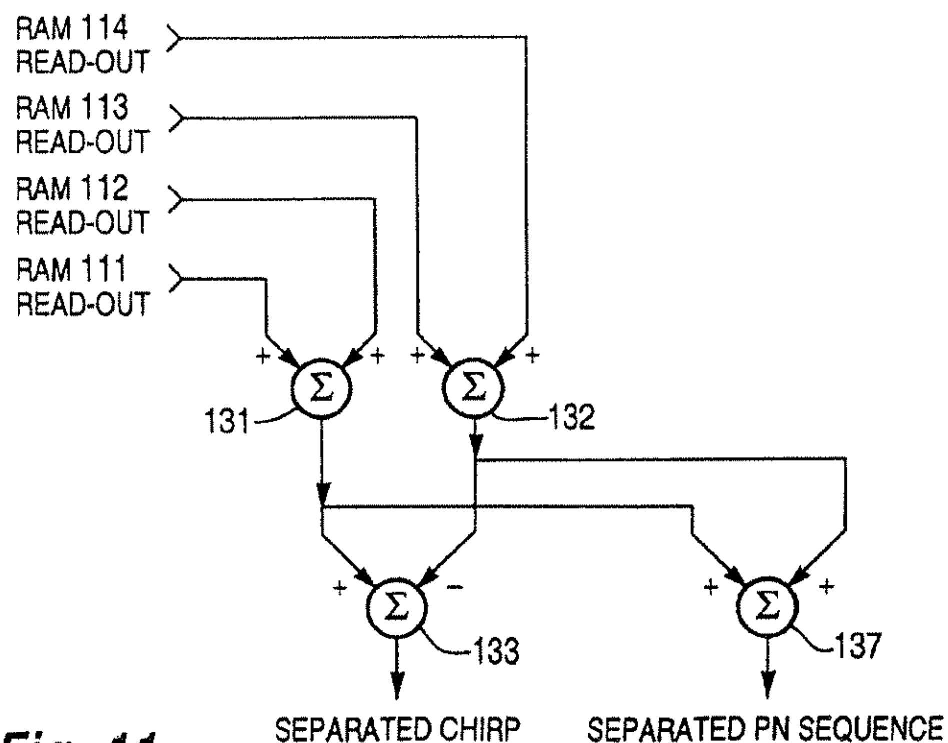

RAM 114
READ-OUT
RAM 113
READ-OUT
RAM 112
READ-OUT
RAM 111
READ-OUT
131
132
133
137
SEPARATED CHIRP
SEPARATED PN SEQUENCE

Fig. 11

GHOST CANCELLATION REFERENCE SIGNAL WITH BESSEL CHIRPS & PN SEQUENCES, & TV RECEIVER USING SUCH SIGNAL

This is a divisional of co-pending application Ser. No. 08/158,299, filed Nov. 29, 1993, which is a continuation-in-part of U.S. patent application Ser. No. 07/872,077, filed Apr. 22, 1992, abandoned, and U.S. patent application Ser. No. 07/984,488, filed Dec. 2, 1992, abandoned.

The invention relates to ghost cancellation reference (GCR) signals for use in a television receiver and to a television receiver employing those GCR signals.

BACKGROUND OF THE INVENTION

At the time U.S. patent application Ser. No. 07/872,077 was filed Subcommittee T-3 of the Advanced Television Systems Committee was meeting to determine a GCR signal for use in the United States. The GCR signal was to be a compromise based from two GCR signals, one using Bessel pulse chirp signals as proposed by U.S. Philips Corp. and one using pseudo noise (PN) sequences as proposed by the David Sarnoff Research Center (DSRC) of Stanford Research Institute. The GCR signals are inserted into selected vertical blanking intervals (VBIs). The GCR signals are used in a television receiver for calculating the adjustable weighting coefficients of a ghost-cancellation filter through which the composite video signals from the video detector are passed to supply a response in which ghosts are suppressed. The weighting coefficients of this ghost-cancellation filter are adjusted so it has a filter characteristic complementary to that of the transmission medium giving rise to the ghosts. The GCR signals can be further used for calculating the adjustable weighting coefficients of an equalization filter connected in cascade with the ghost-cancellation filter, for providing an essentially flat frequency spectrum response over the complete transmission path through the transmitter vestigial-sideband amplitude-modulator, the transmission medium, the television receiver front-end and the cascaded ghost-cancellation and equalization filters.

In the conventional method for cancelling ghosts in a television receiver, the discrete Fourier transform (DFT) of the ghosted GCR signal is divided by the DFT of the non-ghosted GCR signal (which latter DFT is known at the receiver from prior agreement with the transmitter) to obtain as a quotient the DFT transform of the transmission medium giving rise to ghosting; and the inverse DFT of this quotient is then used to define the filter weighting coefficients of a compensating ghost-cancellation filter through which the ghosted composite video signal is passed to obtain a de-ghosted composite video signal. To implement the DFT procedure efficiently, in terms of hardware or of calculations required in software, an integral power of two equal-bandwidth frequency bins are used in the DFT. The distribution of energy in the Philips chirp signal has a frequency spectrum extending continuously across the composite video signal band, in contrast to the DSRC PN sequence in which the distribution of energy does not extend continuously across the composite video signal band, but exhibits nulls in its frequency distribution. Accordingly, when the number of equal-bandwidth frequency bins in the DFT is reduced in order to speed calculation time, more accurate ghost cancellation is obtained with the chirp than with the PN sequence as GCR signal, the inventors observe.

During official testing by the Subcommittee, the DSRC GCR signal has exhibited somewhat better performance in

regard to equalization of the passband after ghosting, which some experts including the Philips engineers, attribute to better filter hardware. Theoretically, equalization calculated over an entire active portion of the VBI, proceeding from the PN sequence, has an accuracy substantially the same as the accuracy available calculating equalization from the chirp signal. The entire length of the Philips chirp signal is needed to have the requisite information to implement equalization over the full composite video signal band. The PN sequence contains pulse transitions each of which transitions has substantially the entire frequency spectrum contained therein. The PN sequence contains many pulse transitions, each of which transitions has component frequencies extending over substantially the entire frequency spectrum. This property of the PN sequence, the inventors observe, permits the calculation of equalization taking samples at a prescribed sampling density only over a limited extent of the GCR signal. Taking samples over only a portion of the GCR signal causes some loss in the accuracy with which equalization can be calculated, particularly under poor signal-to-noise conditions. However, since the number of samples involved in the calculation of weighting coefficients for the equalization filter is reduced, there can be an appreciable increase in the speed with which equalization can be calculated, presuming the calculation is done using an iterative method such as least-mean-squares error reduction. Also, there is reduced complexity, in terms of hardware or of calculations required in software, with regard to calculating the equalization filter weighting coefficients.

At the time U.S. patent application Ser. No. 07/872,077 was filed the composite GCR signals comprised of chirps and PN sequence signals that had been proposed did not make available both a chirp and a PN sequence during the same VBI scan line. Subsequently, the Republic of China has adopted a standard GCR signal in which both a chirp and a PN sequence occur during a VBI scan line in each successive field.

SUMMARY OF THE INVENTION

The inventors observe that making both a chirp and a PN sequence available during each of selected VBI scan lines (e.g., a prescribed VBI scan line in each successive field, facilitates the more rapid and efficient calculations of ghost cancellation and of equalization, on a continuing basis, particularly when the transmission medium exhibits continual change—e.g., during the rapidly changing ghost conditions caused in over-the-air transmissions by overflying aircraft.

A television receiver embodying the invention in one of its aspects includes means for separating the chirp and PN sequence portions of the ghost cancellation reference (GCR) signal from the remainder of the composite video signal, a ghost cancellation filter and an equalization filter connected in cascade to respond to the composite video signal and provided each with adjustable filtering weights, means responding to the separated chirp portion of the GCR signal to calculate its discrete Fourier transform (DFT), means responding to that DFT to determine the adjustable filtering weights of the ghost cancellation filter, and means responding to the separated PN sequence to determine the adjustable filtering weights of the equalization filter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A, 1B, 1C and 1D are waveforms of the ghost cancellation reference signals in selected vertical blanking intervals of four successive fields of video, as embody the invention in one of its aspects.

FIG. 2 is the waveform of a separated chirp signal as formed by differentially combining the sum of the ghost cancellation reference signals of FIGS. 1A and 1B with the sum of the ghost cancellation reference signals of FIGS. 1C and 1D.

FIG. 3 is the waveform of a separated PN sequence as formed by differentially combining the sum of the ghost cancellation reference signals of FIGS. 1A and 1D with the sum of the ghost cancellation reference signals of FIGS. 1B and 1C.

FIG. 4 is a schematic diagram of a television modulator arranged for transmitting the signals of FIGS. 1A, 1B, 1C and 1D.

FIG. 5 is a schematic diagram of a television receiver arranged to receive television signals incorporating the ghost cancellation reference signals of FIGS. 1A, 1B, 1C and 1D, to a suppress ghosts accompanying those television signals and to equalize the transmission channel across the video bandwidth.

FIG. 6 is a schematic diagram of the GCR signal capture processor shown as a block in FIG. 5.

FIGS. 7A, 7B, 7C and 7D are waveforms of the ghost cancellation reference signals in selected vertical blanking intervals of four successive fields of video, as embody the invention in one of its aspects, alternative to the aspect of the invention illustrated by FIGS. 1A, 1B, 1C and 1D.

FIG. 8 is the waveform of a separated chirp signal as formed by combining the ghost cancellation reference signals of FIGS. 7B and 7C, of FIGS. 7D and 7A, or FIGS. 7A, 7B, 7C and 7D.

FIG. 9 is the waveform of a separated PN sequence preceded by a "gray" pedestal, as formed by combining the ghost cancellation reference signals of FIGS. 7A, 7B, 7C and 7D.

FIG. 10 is a schematic diagram of the FIG. 6 serial processor for processing the ghost cancellation reference signals of FIGS. 1A, 1B, 1C and 1D to generate FIG. 2 and FIG. 3 signals.

FIG. 11 is a schematic diagram of the FIG. 6 serial processor for processing the ghost cancellation reference signals of FIGS. 7A, 7B, 7C and 7D to generate the FIG. 8 and FIG. 9 signals.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

FIGS. 1A, 1B, 1C and 1D show the ghost cancellation reference signals in selected scan lines of the vertical blanking intervals of four successive fields of video. Insertion may be into any one (or more) of the 11th through 20th scan lines of each field, the present preference being to replace the vertical interval reference (VIR) signal currently used in the 19th scan line of each field. To simplify the description that follows, insertion of GCR signal into the 19th scan line of each field will be assumed by way of specific illustration.

The ghost cancellation reference signals of FIGS. 1A, 1B, 1C and 1D begin with horizontal synchronization pulses 11, 21, 31 and 41, respectively, which pulses are shown as being negative-going. The leading edges of the horizontal synchronization pulses are considered to be the beginning of VBI scan lines that are each of 63.55 microsecond duration in NTSC standard television signals. The horizontal synchronization pulses 11, 21, 31 and 41 are respectively followed during ensuing back-porch intervals by chroma bursts 12, 22, 32 and 42. The plus and minus signs near the chroma bursts 12, 22, 32 and 42 indicate their relative polarities respective to each other, per the NTSC standard.

Bessel pulse chirps 13, 23, 33 and 43 each of 33 microsecond duration begin 12 microseconds into the VBI scan lines of FIGS. 1A, 1B, 1C and 1D, respectively. The arrows associated with each of these chirps is indicative of its relative polarity with respect to the other chirps; chirp polarity is shown as alternating from frame to frame. These chirps swing plus/minus 40 IRE from 30 IRE "gray" pedestals which extend from 12 to 48 microseconds into these VBI lines. The gray level of the pedestals, the plus/minus swing of the chirps, the duration of the pedestals and the duration of the chirps have been specified to correspond as closely as possible to the Philips system that has been officially tested; and design variations were, at the time U.S. patent application Ser. No. 07/872,077 was filed, expected to occur should the compromise GCR signals described herein be adopted by the Subcommittee as their official recommendation for a standard.

Beginning at 51 microseconds into the VBI scan lines of FIGS. 1A, 1B, 1C and 1D 127-sample PN sequences 14, 24, 34 and 44 respectively occur. Each of the PN sequences 14, 24, 34 and 44 is of the same 9-microsecond duration as the others. The PN sequence in the final field of each frame is of opposite polarity from the PN sequence in the initial field of that frame and is of the same polarity as the PN sequence in the initial field of the next frame, as indicated by the arrows associated with respective ones of the PN sequences 14, 24, 34 and 44. These PN sequences have −1 and +1 values at −15 IRE and +95 IRE levels respectively. These PN sequences have been specified to correspond as closely as possible to the DSRC system that has been officially tested; and design variations were, at the time U.S. patent application Ser. No. 07/872,077 was filed, expected to occur should the compromise GCR signals described herein be adopted by the Subcommittee as their official recommendation for a standard.

There was, at the time U.S. patent application Ser. No. 07/872,077 was filed, opinion within the Subcommittee that the Bessel pulse chirp should be shortened to 17 microsecond duration so ghosts of up to 40 microsecond delay can be cancelled without the restriction that the VBI line following that containing the GCR signal having not to have information therein that changes from field to field. If the Bessel pulse chirp is shortened, the PN sequence could be made to be 255 pulse sample times, rather than 127 pulse sample times, in length. Adjustments to the compromise GCR signals described herein may be made so the swings of the Bessel pulse chirp and the PN sequence correspond, with suitable adjustment of the gray pedestal, if appropriate. The inventors favor the chirp swing being increased to extend over the range between the −15 IRE and +95 IRE levels and the gray pedestal being set at 40 IRE. The lesser range for the chirps was chosen by the Philips engineers for fear of overswing under some conditions, but the inventors believe that IF amplifier AGC will forestall such overswing. Extending the gray pedestal to the beginning of the PN sequence will then provide a signal that when low-pass filtered and subsequently gated during the mid-portion of the scan line will provide a level that is descriptive of 40 IRE level and can be used for automatic gain control of the composite video signal.

FIG. 2 shows the separated Bessel pulse chirp waveform that results when the GCR signals from two successive fields that are in two successive frames are differentially combined, assuming that the GCR signals are of the sort shown in FIGS. 1A, 1B, 1C and 1D. A separated Bessel pulse chirp waveform per FIG. 2 results when the GCR signals of FIGS. 1B and 1C are differentially combined. A

separated Bessel pulse chirp waveform per FIG. 2 also results when the GCR signals of FIGS. 1D and 1A are differentially combined. A separated Bessel pulse chirp waveform per FIG. 2 also results when the sum of the GCR signals of FIGS. 1A and 1B is differentially combined with the sum of GCR signals of FIGS. 1C and 1D.

FIG. 3 shows the waveform that results when the sum of the GCR signals of FIGS. 1A and 1D is differentially combined with he sum of GCR signals of FIGS. 1B and 1C. The Bessel pulse chirp waveform, the "gray" pedestal and the chroma burst are suppressed in this signal; and DC information concerning 0 IRE level is lost. The PN sequence is maintained as a separated PN sequence signal.

FIG. 4 shows in block schematic form a television transmitter for NTSC color television signals into which are inserted GCR signals per FIGS. 1A, 1B, 1C and 1D.

A processing amplifier 50 generates composite video signals proceeding from color video signals and synchronizing signals. By way of example, the color video signals may be red (R), green (G) and blue (B) signals from a studio color camera and the synchronizing signals may be from a studio sync generator that also supplies synchronizing signals to the studio color camera. Alternatively, the color video signals may be from a remote location and the synchronizing signals furnished by a genlock connection. Or, if the local transmitter is a low-power transmitter re-broadcasting signals received over-the-air from a distant high-power transmitter, the color video signals may be generated by demodulating the received composite video signal and the synchronizing signals may be separated from the received composite video signal.

The processing amplifier 50 is shown as including a crystal oscillator 51 furnishing oscillations at eight times color carrier frequency f_c, a counter 52 for counting the number of these oscillations per horizontal scan line, a counter 53 for counting scan lines per field, and a counter 54 for counting modulo-four successive fields of video signal. The processing amplifier 50 supplies its composite video output signal as a first input signal to an analog selector switch 55. The output signal from the analog selector switch 55 is supplied to a video modulator 56 to control the vestigial-sideband amplitude modulation of the video carrier. Sound signal is supplied to a frequency modulator 57. The modulated video and sound carriers are amplified by radio-frequency amplifiers 58 and 59, respectively, and the output signals from the amplifiers 58 and 59 are combined in a coupling network 60 to a broadcast antenna 60. A number of cariants of the conventional television transmitter arrangements described in this and the previous paragraph are known to those familiar with television transmitter design.

The analog selector switch 55 corresponds to that previously known for inserting the vertical interval reference (VIR) signal. A decoder 62 detects those portions of the count from the counter 52 associated with the "active" portions of horizontal scan lines i.e., the portions of horizontal scan lines exclusive of the horizontal blanking intervals - to generate a logic ONE. A decoder 63 responds to the scan line count from the counter 53 to decode the occurrence of the 19th scan line in each field and generate a logic ONE. An AND gate 64 responds to these logic ONEs occurring simultaneously to condition the analog selector switch 55 to select a second input signal for application to the video modulator 56, rather than the composite video signal furnished from the processing amplifier 50 to the analog selector switch 55 as its first input signal. This second signal is not the VIR signal, however, but is in successive fields successive ones of the GCR signals depicted in FIGS. 1A, 1B, 1C and 1D (or, alternatively, in FIGS. 7A, 7B, 7C and 7D).

These GCR signals are stored in digitized form in a read-only memory 65. A first portion of the address for the ROM 65 is supplied from the counter 54, the modulo-four field count selecting which of the GCR signals depicted in FIGS. 1A, 1B, 1C and 1D is to be inserted in the current field. A second portion of the address for the ROM 65 is supplied from the counter 52 and scans the selected one of the GCR signals depicted in FIGS. 1A, 1B, 1C and 1D. The digitized GCR signal read from the ROM 65 is supplied to a digital-to-analog converter 66. The resulting analog GCR signal is supplied as the second input signal to the analog selector switch 55 for insertion into the "active" portion of the 19th line of the field.

FIG. 5 depicts a television receiver arranged to receive television signals incorporating the ghost cancellation reference signals of FIGS. 1A, 1B, 1C and 1D. Television signals collected by an antenna 70 are amplified by a radio-frequency amplifier 71 and then down-converted to an intermediate frequency by a converter 72. An intermediate-frequency amplifier 73 supplies to a video detector 74 and to a sound detector 75 amplified response to the intermediate-frequency signals from the converter 72. The sound detector 75 demodulates the frequency-modulated sound carrier and supplies the resulting sound detection result to audio electronics 76. The audio electronics 76, which may include stereophonic sound detection circuitry, includes amplifiers for supplying amplified sound-descriptive electric signals to loudspeakers 77 and 78.

The video detector 74 supplies analog composite video signal to an analog-to-digital converter 79, to a burst detector 80, to a horizontal sync separator 81 and to a vertical sync separator 82. The separated horizontal synchronizing pulses from the horizontal sync separator 81 and the separated vertical synchronizing pulses from the vertical sync separator 82 are supplied to kinescope deflection circuitry 83, which generates deflection signals for a kinescope 84. A burst gate generator 85 generates a burst gate signal an appropriate interval after each horizontal sync pulse it is supplied from the horizontal sync separator 81. This burst gate signal keys the burst detector 80 into operation during chroma burst interval. The burst detector 80 is included in a phasi-locking loop for a phase-locked oscillator 86. The phase-locked oscillator 86 oscillates at a frequency sufficiently high that the analog-to-digital converter 79 sampling the analog composite video signal from the video detector 74 once with each oscillation over-samples that signal. As is well-known, it is convenient from the standpoint of simpler digital hardware design that phase-locked oscillator 86 oscillate at a frequency that is an integral power of two greater than the 3.58 MHz color subcarrier frequency. Sampling chroma signals four or eight times per cycle is preferred.

The separated horizontal sync pulses from the horizontal sync separator 81 are supplied to a scan line counter 87 for counting, the scan line count from which counter 87 is reset to zero at the outset of each vertical sync interval by separated vertical sync pulses from the vertical sync separator 82. Indication in the count from the counter 87 of the occurence of the 19th scan line in each field is detected by a decoder 88. Indication in the count from the counter 87 of the occurence of the 20th scan line in each field is detected by a decoder 89. The occurences of the 19th and 20th scan line in each field is signaled to a GCR signal capture processor 90, which captures the GCR signals in the 19th

scan line of each field of digital composite video signal from the analog-to-digital converter 79. This capturing process will be described in greater detail in connection with the description of FIG. 6.

The GCR signal capture processor 90 includes circuitry for separating the Bessel pulse chirp portion of the captured GCR signals, which portion is supplied to a ghost-cancellation filter weight computer 91. The GCR signal capture processor 90 also includes circuitry for separating the PN sequence portion of the captured GCR signals, which portion is supplied to an equalization filter weight computer 92. The digitized composite video signal from the analog-to-digital converter 79 is supplied via a cascade connection of a ghost-cancellation filter 93 and an equalization filter 94 to a luma/chroma separator 95. The ghost-cancellation filter 93 has filtering weights adjustable in response to results of the computations by the ghost-cancellation filter weight computer 91, and the equalization filter 94 has filtering weights adjustable in response to results of the computations by the equalization filter weight computer 92.

The ghost-cancellation filter weight computer 91 is preferably of a type in which the discrete fourier transform Transform (DFT) of the ghosted GCR signal is divided by the DFT of the non-ghosted GCR signal to obtain as a quotient the DFT transform of the transmission medium giving rise to ghosting; and the inverse DFT of this quotient is then used to define the filter weighing coefficients of a compensating ghost-cancellation filter. As known by those skilled in the ghost-cancellation art, the ghost-cancellation filter 93 is preferably of a type with a sparse kernel where the positioning of the non-zero filter weights can be shifted responsive to results from the ghost-cancellation filter weight computer 91. A ghost-cancellation filter with a dense kernel would typically require 2048 filter weights, which would be difficult to construct in actual practice.

The equalization filter weight computer 92 could be of a type performing calculations using DFTs, the results of which are subject to inverse-DFT in order to define the filter weighing coefficients of a compensating equalization filter 94. Preferably, however, the equalization filter weight computer 92 is of a type using a least-mean-square error method to perform an interative adjustment of a 15-tap or so digital FIR filter used as the equalization filter 94, adjustment being made so that there is a best match to the (sin x)/x function of the result of correlating of a portion of the de-ghosted PN sequence with the corresponding portion of the PN sequence known at the receiver as being a standard.

The luma/chroma separator 95 is preferably of a type using digital comb filtering for separating a digital luminance signal and a digital chroma signal from each other, which signals are respectively supplied to digital luminance processing circuitry 96 and to digital chrominance processing circuitry 97. The digital luminance (Y) signal from the digital luminance processing circuitry 96 and the digital I and Q signals from the digital chrominance processing circuitry 97 are supplied to a digital color matrixing circuit 98. Matrixing circuit 98 responds to the digital Y, I and Q signals to supply digital red (R), green (G) and blue (B) signals to digital-to-analog converters 99, 100 and 101, respectively. Analog red (R), green (G) and blue (B) signals are supplied from the digital-to-analog converters 99, 100 and 101 to R, G and B kinescope driver amplifiers 102, 103 and 104, respectively. The R, G and B kinescope driver amplifiers 102, 103 and 104 supply red (R), green (G) and blue (B) drive signals to the kinescope 84.

The filter 94 has thusfar been termed an "equalization filter" and considered to be a filter that would provide a flat frequency response through the band, which is the way this filter has been characterized by other workers in the ghost-cancellation art. In practice it is preferable to adjust the filter weights in the filter 94, not for flat frequency response through the band, but with a frequency response known to provide some transient over- and under-shooting, or video peaking. This reduces the need for providing transient overshooting or video peaking in the digital luma processing circuitry 96.

FIG. 6 shows a representative way of constructing the GCR signal capture processor 90. Random access memories 111, 112, 113 and 114 are arranged to serve as line stores for the GCR reference signals supplied during fields 00, 01, 10 and 11 of each cycle of four successive fields of digitized composite video signal. These GCR reference signals are supplied to the respective input ports of the RAMs 111, 112, 113 and 114 from the analog-to-digital converter 79. The four successive fields in each cycle are counted modulo-4 by a two-stage binary counter 115 that counts the ONEs generated by a decoder 116 that detects indications of the last scan line in a field furnished by the scan line count from the counter 87. As a preparatory measure in the procedure of updating the filter weighting coefficients in the ghost-cancellation filter 93 and in the equalization filter 94, the proper phasing of the modulo-4 field count can usually be determined by correlating the most recently received GCR signal, as de-ghosted, with each of the four standard GCR signals stored in the receiver, looking for best match. Decoders 121, 122, 123 and 124 decode the 100, 101, 110 and 111 signals as generated by the 19th line decoder 88 supplying most significant bit and field count from the field counter 115 supplying the two less significant bits, thereby to furnish write enable signals sequentially to the RAMs 111, 112, 113 and 114 during the 19th scan lines of successive fields.

The RAMs 111, 112, 113 and 114 are addressed in parallel by an address counter 125 that counts the number of samples per scan line. The address counter 125 receives the oscillations from the phase-locked oscillator 86 at its count input connection, and is reset by an edge of the horizontal sync pulse. This addressing scan during the 19th scan line allocates each successive digital composite video signal sample to a successive addressable location in the one of the RAMs 111, 112, 113 and 114 receiving a write enable signal. During the 20th scan line the decoder 89 provides a read enable signal to all of the RAMs 111, 112, 113 and 114. The addressing scan the counter 125 provides the RAMs 111, 112, 113 and 114 during the 20th scan line reads out the four most recently received and stored GCR signals parallely to a serial processor 126 that combines them to generate sequential samples of a separated Bessel pulse chirp signal and sequential samples of a separated PN sequence.

During the 20th scan line, the decoder 89 also provides a write enable signal to RAMs 127 and 128 that respectively serve as line stores for the separated chirp signal and separated PN sequence. The decoder 89 at the same time conditions address multiplexers 129 and 130 to select addresses from the address counter 125 as write addressing for the RAMs 127 and 128 respectively. The counter 125 provides the RAM 127 the addressing scan needed to write thereinto the sequential samples of the separated chirp signal from the serial processor 126. The counter 125 also provides the RAM 128 the addressing scan needed to write thereinto the sequential samples of the separated PN sequence from the serial processor 126. At times other than the 20th scan line, the address multiplexer 129 selects to the RAM 127 read addressing supplied to its RA terminal from the ghost-cancellation filter weight computer 91 during data fetching

operations, in which operations the computer **91** also supplies the RAM **127** a read enable signal. The RAM **127** supplies at times other than the 20th scan line, the address multiplexer **130** selects to the RAM **128** read addressing supplied to its RA terminal from the equalization filter weight computer **92** during data fetching operations, in which operations the computer **42** also supplies the RAM **128** a read enable signal. The RAMs **127** and **128** have respective O terminal for supplying read output signals the ghost-cancellation filter weight computer **91** and to the equalization filter weight computer **92**, respectively.

FIGS. **7A**, **7B**, **7C** and **7D** are waveforms of the ghost cancellation reference signals in selected vertical blanking intervals of four successive fields of video, as embody the invention in one of its aspects, alternative to the aspect of the invention which FIGS. **11A**, **11B**, **11C** and **11D** concern. The GCR signals in FIGS. **7A** and **7D** are the same as those of FIGS. **1A** and **1D**. The GCR signals in FIGS. **7B** and **7C** differ from those of FIGS. **1B** and **1C** in that the swings of the PN sequences are reversed in direction. In FIGS. **7B** and **7C** the swings of the PN sequences **24'** and **34'** are in the same direction as the swings of the PN sequences **14** and **44** in FIGS. **7A** and **7D**.

FIG. **8** shows the separated Bessel pulse chirp waveform that results when the GCR signals from two successive fields that are in two successive frames are differentially combined, assuming that the GCR signals are of the sort shown in FIGS. **7A**, **7B**, **7C** and **7D**. A separated Bessel pulse chirp waveform per FIG. **8** results when the GCR signals of FIGS. **7B** and **7C** are differentially combined. A separated Bessel pulse chirp waveform per FIG. **8** also results when the GCR signals of FIGS. **7D** and **7A** are differentially combined. A separated Bessel pulse chirp waveform per FIG. **8** also results when the sum of the GCR signals of FIGS. **7A** and **7B** is differentially combined with the sum of the GCR signals of FIGS. **7C** and **7D**.

FIG. **9** shows the waveform that results when the GCR signals from four (or any multiple of four) successive fields are additively combined or are averaged, assuming that the GCR signals are of the sort shown in FIGS. **7A**, **7B**, **7C** and **7D**. The Bessel pulse chirp waveform and the chroma burst are suppressed in this signal. The DC level and "gray" pedestal are maintained in this signal as well as the PN sequence. The PN sequence can then be separated by high-pass digital filtering. The DC level and "gray" pedestal can be separated by low-pass digital filtering. The DC level and "gray" pedestal are useful in circuitry for controlling the gain and DC-offset of the analog composite signal applied to the analog-to-digital converter **79**. Circuits are known in the prior art in which the digital output signal of an analog-to-digital converter is selected as input signal to a first digital comparator during a portion of the digitized composite video signal known to be supposedly at 0 IRE level, there to be compared against digitized ideal 0 IRE level to develop a first digital error signal that is converted to analog error by a digital-to-analog converter and fed back to degenerate error in the 0 IRE level against which the input signal to the analog-to-digital converter is DC-restored. In certain of these circuits the digital output signal of the same analog-to-digital converter is selected as input signal to a second digital comparator during a portion of the digitized composite video signal known to be supposedly at a prescribed pedestal level, there to be compared against the prescribed pedestal level in digital form to develop a second digital error signal that is converted to analog error by a digital-to-analog converter and fed back as an automatic gain control (AGC) signal to a gain-controlled amplifier preceding the analog-to-digital converter and keeping the input signal to the analog-to-digital converter quite exactly within the bounds of the conversion range.

FIG. **10** shows how the FIG. **6** serial processor may be constructed for processing the ghost cancellation reference signals of FIGS. **1A**, **1B**, **1C** AND **1D** to generate the FIG. **2** and FIG. **3** signals. A serial adder **131** sums the RAM **111** output signal per FIG. **1A** with the RAM **112** output signal per FIG. **1B**. A serial adder **132** sums the RAM **113** output signal per FIG. **1C** with the RAM **114** output signal per FIG. **1D**. A serial subtractor **133** subtracts the sum output of the adder **132** from the sum output of the adder **131** to generate a separated Bessel pulse chirp signal. With a bit point shift of two places towards less significance, for carrying out wired division by four, this separated Bessel pulse chirp signal is the FIG. **2** signal. A serial adder **134** sums the RAM **111** output signal per FIG. **1A** with the RAM **114** output signal per FIG. **1D**. A serial adder **135** sums the RAM **112** output signal per FIG. **1B** with the RAM **113** output signal per FIG. **1C**. A serial subtractor **136** subtracts the sum output of the adder **135** from the sum output of the adder **134** to generate a separated PN sequence signal. With a bit point shift of two places towards less significance, for carrying out wired division by four, this separated PN sequence signal is the FIG. **3** signal.

FIG. **11** shows how the FIG. **6** serial processor may be constructed for processing the ghost cancellation reference signals of FIGS. **7A**, **7B**, **7C** and **7D** to generate the FIG. **8** and FIG. **9** signals. Serial adders **131** and **132** and serial subtractor **133** cooperate to generate a separated Bessel pulse chirp signal, as described in connection with FIG. **10**. With a bit point shift of two places towards less significance, for carrying out wired division by four, this separated Bessel pulse chirp signal is the FIG. **8** signal. A serial adder **137** sums the sum outputs of the adders **131** and **132** to generate a separated PN sequence signal. With a bit point shift of two places towards less significance, for carrying out wired division by four, this separated PN sequence signal is the FIG. **9** signal.

The foregoing description assumes that only one VBI scan line per field is made available by television broadcasters. The availability of two successive VBI scan lines in each field allows their being added to cancel color burst within the period of a single scan line, lessening the possibility that fast fading conditions will lead to imperfect cancellation of color burst or to misalignment of GCR signals when they are combined. Also, the time required to acquire the data necessary for the calculations of ghost cancellation and equalization parameters is halved. By way of example, the GCR signals of FIGS. **1A** and **1B** could be in the 19th and the 20th scan lines of the first field of each frame; and the GCR signals of FIGS. **1C** and **1D** could be in the 19th and 20th scan lines of the second field of each frame. Alternatively, by way of further example, the GCR signals of FIGS. **7A** and **7B** could be in the 19th and the 20th scan lines of the first field of each frame; and the GCR signals of FIGS. **7C** and **7D** could be in the 19th and the 20th scan lines of the second field of each frame.

The FIG. **5** television receiver can be modified to include a 1H delay line connected at its input to receive video signal from the video detector **74**. This facilitates addition of the 19th and the 20th scan lines of each field being done in the analog regime by adding the signals at the input and output of a 1H delay line to supply input signal to the ADC **79**. Where the GCR signals of FIGS. **7A**–**7D** are used, the color burst is cancelled and both the chirp and PN sequence signals are strengthened prior to digitization by the ADC **79**.

This reduces errors arising from round-off during digitization and from the sampling during digitization not being timed exactly the same from line to line. The decoders **88** and **89** are modified to detect scan lines **20** and **21**, thus taking into account the delay introduced by the 1 H delay line. Alternatively, modifications of the FIG. **5** television receiver can be such that the 19th and the 20th scan lines of each field are combined in the digital regime; this is done through suitable modification of the GCR signal capture processor, changing the read and write addressing of the GCR line-store RAMs therein. Instead of including GCR signal components in the 19th and the 20th scan lines of each field, GCR signal can be included in the 18th and the 19th scan lines of each field. In still other alternatives, GCR signal components are included in the 18th and the 20th scan lines of each field, so that horizontal sync as well as color burst portions of the signal can be suppressed by differentially combining the corresponding pixels of the two scan lines, while anti-phase chirp or PN sequence components combine constructively.

The voluntary standard for GCR signals in the United States is now the U.S. Philips Corp. proposal using Bessel chirps. The voluntary standard is described in a paper by L. D. Claudy and S. Herman entitled "GHOST CANCELING: A New Standard for NTSC Broadcast Television" and presented 17 Sep. 1992 at the IEEE Broadcast Technology Symposium in Washington D.C. The foregoing teachings in regard to television receiver design have application to GCR signals per the voluntary standard, particularly with regard to the GCR signal capture processor and to the extraction of chirp pedestal information. The GCR signals of the voluntary standard are inserted into the 19th line of each field and repeat in an eight-field cycle, rather than the four-field cycle explicitly described above. The GCR signal capture processor **90** as shown in FIG. **6** is readily modified to augment the modulo-4 field counter **115** with an additional counter stage or two, thereby to provide a modulo-8 field counter or a modulo-16 field counter; to add additional GCR signal line store RAMs for storing one or two eight-field cycles of the GCR signals of the voluntary standard; and to add field-count decoders for selectively writing the additional GCR signal line store RAMs. Initial rough calculations of ghost cancellation parameters may be made by combining only a pair of the GCR signals of the voluntary standard, so as to separate chirp signal, with a greater number of pairs of GCR signals being combined later on to support refined calculations of ghost cancellation parameters. The computation of equalizing parameters for application to the equalization filter **94** is done proceeding from the separated Bessel chirp, rather than from a separated PN sequence, of course.

Further refinements in the inventor's GCR signal capture processor are described in their U.S. patent application Ser. No. 07/984,488 filed 2 Dec. 1992 and entitled GHOST CANCELATION REFERENCE SIGNAL ACQUISITION CIRCUITRY, AS FOR TV RECEIVER OR VIDEO RECORDER, the drawing and specification of which are appended hereto for incorporation herein.

One skilled in the art of electronic circuits and systems design and acquainted with the foregoing disclosure will be enabled to design a number of variants of the signals and circuits specifically disclosed; and this should be borne in

mind when considering the respective scopes of the claims which follow.

Appendix

What is claimed is:

1. A television receiver for use with ghost-cancellation-reference signals of a type that include both a chirp and a pseudo-noise sequence in a selected scan line of a vertical blanking interval of each field of a composite video signal, said television receiver comprising:

means for separating the chirp and pseudo-noise sequence portions of the ghost-cancellation-reference signals from the remainder of the composite video signal; and

a ghost cancellation filter provided with adjustable filtering weights; an equalization filter provided with adjustable filtering weights and connected in cascade with said ghost cancellation filter to respond to the composite video signal;

means responding to the separated chirp portions of the ghost-cancellation-reference signals to calculate a discrete Fourier transform therefrom;

means responding to said discrete Fourier transform to determine values of the adjustable filtering weights of the ghost cancellation filter; and

means responding to the separated pseudo-noise sequence portions of the ghost-cancellation-reference signals to determine values of the adjustable filtering weights of the equalization filter.

2. A television receiver as set forth in claim **1**, wherein said means for separating the chirp and pseudo noise sequence portions of the ghost-cancellation-reference signals from the remainder of the composite video signal comprises:

means for selecting scan lines with said ghost-cancellation-reference signals from the vertical blanking interval of each field;

means for additively and subtractively combining selected scan lines in sets of four successive ones of said selected scan lines, so as to separate the chirp portions of the ghost-cancellation-reference signals from a remainder of the composite video signal; and

means for additively and subtractively combining selected scan lines in sets of four successive ones of said selected scan lines, so as to separate the pseudo noise sequence portions of the ghost-cancellation-reference signals from a remainder of the composite video signal.

3. A television receiver for receiving television signals of a type wherein a composite video signal including a ghost-cancellation reference signal therewithin is transmitted, said ghost-cancellation reference signal including within an active portion of each of selected scan lines both a chirp signal and a subsequent pseudo-noise sequence, wherein in each pair of successive pairs of said selected scan lines both scan lines have respective chirp signals of the same sense as each other, wherein within each said pair of selected scan lines the two scan lines have respective pseudo noise sequences of opposite sense to each other, wherein successive ones of said selected scan lines occur in successive vertical blanking intervals of said composite video signal, and wherein the two selected scan lines in each succeeding said pair of selected scan lines have respective chirp signals of opposite sense to the respective chirp signals in the preceding said pair of selected scan lines, said television receiver comprising:

means for responding to a selected one of said television signals to supply said composite video signal;

means for additively and subtractively combining selected scan lines in sets of four successive ones of said selected scan lines so as to separate chirp portions of the ghost-cancellation-reference signals from a remainder of said composite video signal;

means for additively and subtractively combining selected scan lines in sets of four successive ones of said selected scan lines so as to separate the pseudo noise sequence portions of the ghost-cancellation-reference signals from a remainder of said composite video signal;

a ghost cancellation filter provided with adjustable filtering weights;

an equalization filter provided with adjustable filtering weights and connected in cascade with said ghost cancellation filter to respond to said composite video signal;

means responding to the separated chirp portions of the ghost-cancellation-reference signals to calculate a discrete Fourier transform therefrom;

means responding to said discrete Fourier transform to determine values of the adjustable filtering weights of the ghost cancellation filter; and

means responding to the separated pseudo noise sequence portions to determine values of the adjustable filtering weights of the equalization filter.

4. A television receiver for television signals including ghost-cancellation-reference signals of a type that include chirp information comprising a single chirp with pedestal in a selected scan line of the vertical blanking interval of each field, consecutive ones of which chirps alternate being first and second senses in a prescribed pattern, said television receiver comprising:

means for responding to a selected one of said television signals to supply a composite video signal;

means for separating the chirp information from a remainder of said composite video signal, including;

means for selecting an even-numbered plurality of said scan lines with chirps from respective ones of said vertical blanking intervals, and

means for combining corresponding samples of said even-numbered plurality of said selected scan lines to generate respective samples of said chirp information without accompanying pedestal;

a ghost cancellation filter provided with adjustable filtering weighs; and

means responding to the separated chirp information for computing values for the adjustable filtering weights of the ghost cancellation filter.

5. A television receiver as set forth in claim 4, wherein said means responding to the separated chirp information for computing values of the adjustable filtering weights of the ghost cancellation filter comprises:

means responding to the separated chirp information of the ghost-cancellation-reference signals to calculate a discrete Fourier transform therefrom; and

means responding to said discrete Fourier transform to determine the values of the adjustable filtering weights of the ghost cancellation filter.

6. A television receiver as set forth in claim 5 wherein said even-numbered plurality of said selected scan lines includes four scan lines.

7. A television receiver as set forth in claim 5 wherein said even-numbered plurality of said selected scan lines includes a multiple of four scan lines.

8. A television receiver as set forth in claim 4 wherein said even-numbered plurality of said selected scan lines includes four scan lines.

9. A television receiver as set forth in claim 4 wherein said even-numbered plurality of said selected scan lines includes a multiple of four scan lines.

10. A television receiver as set forth in claim 4, including means for separating information concerning the pedestals of said chirp information, separated from said chirp information, which means comprises:

means for selecting an even-numbered plurality of said scan lines with chirps from respective ones of said vertical blanking intervals, and

means for combining corresponding samples of said even-numbered plurality of said selected scan lines to generate respective samples of said information concerning the pedestals of said chirp information, separated from said chirp information.

11. A television receiver for television signals including ghost-cancellation-reference signals of a type that include chirp information and pedestal information together comprising a single chirp with pedestal in a selected scan line of a vertical blanking interval of each field, consecutive ones of which chirps alternate being first and second senses in a prescribed pattern, said television receiver including:

means for responding to a selected one of said television signals to supply a composite video signal;

means for separating said pedestal information from said chirp information, which means comprises:

means for selecting an even-numbered plurality of said scan lines with chirps from respective ones of said vertical blanking intervals, and means for combining corresponding samples of said even-numbered plurality of said selected scan lines to generate respective samples of said pedestal information separated from said chirp information.

12. A television receiver for television signals including ghost-cancellation-reference signals of a type that include a single chirp with pedestal in a selected scan line of the vertical blanking interval of each field, consecutive ones of which chirps alternate being first and second senses in a prescribed patter, said television receiver comprising:

means for responding to a selected one of said television signals to supply a composite video signal;

means for separating chirp information from the remainder of the composite video signal, including:

means for selecting an even-numbered plurality of said scan lines with chirps from respective ones of said vertical blanking intervals, said even-numbered plurality being a multiple of four, each of which selected scan lines includes front porch, horizontal synchronizing pulse, back porch, color burst and a pedestal for the chirp therewithin;

means for combining corresponding samples of said even-numbered plurality of said selected scan lines to generate respective samples of said chirp information without accompanying front porch, horizontal synchronizing pulse, back porch, color burst or pedestal;

a ghost cancellation filter provided with adjustable filtering weights; and means responding to the separated chirp information for computing values of the adjustable filtering weights of the ghost cancellation filter.

13. A communication system, comprising:

means for generating video signals;

means for inserting ghost canceling reference signals in each vertical blanking interval of said video signals, said ghost canceling reference signals comprising pseudo-random noise sequences and chirp signals of different predefined signal characteristics;

transmission means for enabling transmission of said video signals containing said ghost canceling reference signals; and

ghost canceling means for enabling reception of said video signals containing said ghost canceling reference signals transmitted by said transmission means and processing said ghost canceling reference signals contained in said received video signals to eliminate channel transmission delay distortion, said ghost canceling means comprising:

means for separating the chirp signals and the pseudo-random noise sequences of the ghost cancellation reference signals from the received video signals;

a ghost cancellation filter provided with adjustable filtering weights;

an equalization filter provided with adjustable filtering weights and connected in cascade with said ghost cancellation filter to respond to the received video signals;

means responding to the separated chirp signals to calculate a discrete Fourier transform therefrom;

means responding to said discrete Fourier transform to determine the adjustable filtering weights of said ghost cancellation filter for enabling said ghost cancellation filter to cancel ghost components of said received video signals resulting from said channel transmission delay distortion; and

means responding to the separated pseudo-random noise sequences to determine the adjustable filtering weights of said equalization filter for enabling said equalization filter to provide a flat spectrum over the entire frequency range for said ghost cancellation reference signals transmission.

14. A communication system as claimed in claim 13, wherein said pseudo-random noise sequences and chirp signals are included within an active portion of each of selected scan lines in each vertical blanking interval, and within each of said selected scan lines in each vertical blanking interval said chirp signals precede said pseudo-random noise sequences.

15. An apparatus for receiving a plurality of signals divided into a plurality of cyclic fields, each including field synchronization signals and a vertical blanking period which further includes a plurality of horizontal scanning periods, wherein at least two of said horizontal scanning periods in a single vertical blanking period include two different reference signals, one of said reference signals being a pseudo-random noise sequence and the other being a chirp signal, said apparatus including a channel characterization means comprising:

a reference signal processing means for processing said received signals including said two different reference signals in said two horizontal scanning periods within said single vertical blanking period, said reference signal processing means comprising:

means for separating said chirp signal and said pseudo-random noise sequence of said reference signals from said received signals;

a ghost cancellation filter provided with adjustable filtering weights;

an equalization filter provided with adjustable filtering weights and connected in cascade with said ghost cancellation filter to respond to said received signals;

means responding to the separated chirp signals of said reference signals to calculate a discrete Fourier transform therefrom;

means responding to said discrete Fourier transform to determine values of the adjustable filtering weights of the ghost cancellation filter; and

means responding to the separated pseudo-random noise sequence of said reference signals to determine values of the adjustable filtering weights of the equalization filter.

16. The apparatus of claim 15, wherein said means for separating said chirp signal and said pseudo-random noise sequence of said reference signals from said received signals comprises:

means for selecting scan lines with said reference signals from said vertical blanking interval of each cyclic field;

means for additively and subtractively combining selected scan lines in sets of four successive horizontal scanning periods so as to separate said chirp signal of said reference signals from a remainder of said received signals; and

means for additively and subtractively combining selected scan lines in sets of four successive horizontal scanning periods so as to separate said pseudo-random noise sequence of said reference signals from a remainder of said received signals.

17. A receiver for receiving a television signal divided into a plurality of successive fields each comprising a prescribed number of lines of information, said lines being of uniform respective duration, a prescribed single line of each of said fields including a first ghost-cancellation reference signal and a second ghost-cancellation reference signal different than said first ghost-cancellation reference signal, the relative phases of said first and said second ghost-cancellation reference signals varying from field to field in prescribed pattern, said first ghost-cancellation reference signal having a prescribed first duration longer than half a line duration and said second ghost-cancellation reference signal comprising a pseudo-noise (PN) sequence and having a prescribed second duration shorter than half a line duration, said receiver apparatus comprising:

circuitry for separating said first ghost-cancellation reference signal and any ghosting thereof from said second ghost-cancellation reference signal and any ghosting thereof;

circuitry for characterizing a reception channel responsive to said first ghost-cancellation reference signal and said any ghosting thereof; and

an adaptive filter for said television signal, the parameters of which adaptive filter are adjusted responsive to said characterizing of the reception channel for suppressing ghosting in the response of said adaptive filter.

18. The receiver of claim 17, wherein said circuitry for characterizing the reception channel includes:

a read-only memory operated to supply the discrete Fourier transform of a first ideal signal corresponding to said first ghost-cancellation reference signal without any attendant ghosting;

circuitry for calculating the discrete Fourier transform of said first ghost-cancellation reference signal as received with ghosting and separated from said second ghost-cancellation reference signal, and dividing the terms of the discrete Fourier transform of said sepa-

rated first ghost-cancellation reference signal as received with ghosting by corresponding terms of said discrete Fourier transform of said first ideal signal supplied from said read-only memory, thereby to generate a discrete Fourier transform characterizing the reception channel.

19. The receiver of claim 17, wherein said adaptive filter is a ghost cancellation filter, said receiver further comprising:

circuitry for separating said second ghost-cancellation reference signal and any ghosting thereof from said first ghost-cancellation reference signal and any ghosting thereof,

a read-only memory operated to supply the discrete Fourier transform of a second ideal signal corresponding to said second ghost-cancellation reference signal without any attendant ghosting;

circuitry for calculating the discrete Fourier transform of said second ghost-cancellation reference signal as received with ghosting and separated from said first ghost-cancellation reference signal, and dividing the terms of the discrete Fourier transform of said separated second ghost-cancellation reference signal as received with ghosting by corresponding terms of said discrete Fourier transform of a second ideal signal supplied from said read-only memory, thereby to generate a discrete Fourier transform characterizing the reception channel; and

a further adaptive filter for said television signal, the parameters of which adaptive filter are adjusted responsive to said characterizing of the reception channel, for reducing the departure of the spectral response of said reception channel from a desired spectral response.

20. The receiver of claim 17, wherein said adaptive filter is a ghost cancellation filter, said receiver further comprising:

circuitry for separating said second ghost-cancellation reference signal and any ghosting thereof from said first ghost-cancellation reference signal and any ghosting thereof;

circuitry responsive to said second ghost-cancellation reference signal and said any ghosting thereof for calculating the departure of the spectral response of said reception channel from a desired spectral response; and

a further adaptive filter for said television signal, the parameters of which adaptive filter are adjusted for reducing the departure of the spectral response of said reception channel from said desired spectral response.

21. A receiver comprising:

detection circuitry for recovering a digitized baseband signal by detecting a transmitted signal having a succession of frames, each of said frames comprising an odd-numbered field followed by an even-numbered field, each of said fields comprising a specified number of lines with only a particular one of said lines being designated to carry a respective transmission equalization reference signal comprising a first component transmission equalization reference signal and a second component transmission equalization reference signal, said first component transmission equalization reference signals being of the same amplitude and sense of polarity in both said odd-numbered field and said even-numbered field of each said frame, said second component transmission equalization reference signals being the same in amplitude in both said odd-numbered field and said even-numbered field of each said frame but opposite in sense of polarity;

circuitry for separating from said digitized baseband signal said lines designated for carrying a respective transmission equalization reference signal;

memory for temporarily storing a number of said designated lines as separated;

combining circuitry for separating said second component transmission equalization reference signal from said transmission equalization reference signals by combining a most current one of said designated lines with at least one temporarily stored previous one of said designated lines;

an equalization filter with adjustable filtering weights, said equalization filter connected for responding to said digitized baseband signal; and

an equalization weight computer responding to said second component transmission equalization reference signal separated by said combining circuitry to determine said adjustable filtering weights of the equalization filter.

22. The receiver of claim 21, further characterized in that each said second component transmission equalization reference signal comprises a pseudo-noise (PN) sequence of a prescribed first length.

23. The receiver of claim 22, further characterized in that said combining circuitry is of a type for separating said PN sequences of said prescribed first length from said transmission equalization reference signals by differentially combining said designated lines that are in different fields of the same frame.

24. The receiver of claim 21 further characterized in that, in each said particular one of said lines that is designated for carrying a respective transmission equalization reference signal, said second component transmission equalization reference signal is of shorter duration than said first component transmission equalization reference signal.

25. The receiver of claim 24 further characterized in that, in each said particular one of said lines that is designated for carrying a respective transmission equalization reference signal, said second component transmission equalization reference signal follows said first component transmission equalization reference signal.

26. The receiver of claim 25, further characterized in that each said second component transmission equalization reference signal comprises a pseudo-noise (PN) sequence of a prescribed first length.

27. The receiver of claim 26, further characterized in that said combining circuitry is of a type for separating said PN sequences of said prescribed first length from said transmission equalization reference signals by differentially combining said designated lines that are in different fields of the same frame.

28. The receiver of claim 24, further characterized in that each said second component transmission equalization reference signal comprises a pseudo-noise (PN) sequence of a prescribed first length.

29. The receiver of claim 28, further characterized in that said combining circuitry is of a type for separating said PN sequences of said prescribed first length from said transmission equalization reference signals by differentially combining said designated lines that are in different fields of the same frame.

30. The receiver of claim 21, further characterized in that said combining circuitry is of a type for separating said second component transmission equalization reference sig-

nals by combining an even number, at least four, of said designated lines.

31. The receiver of claim 30, further characterized in that each said second component transmission equalization reference signal comprises a pseudo-noise (PN) sequence of a prescribed first length.

32. The receiver of claim 30 further characterized in that, in each said particular one of said lines that is designated for carrying a respective transmission equalization reference signal, said second component transmission equalization reference signal is of shorter duration than said first component transmission equalization reference signal.

33. The receiver of claim 32 further characterized in that, in each said particular one of said lines that is designated for carrying a respective transmission equalization reference signal, said second component transmission equalization reference signal follows said first component transmission equalization reference signal.

34. The receiver of claim 33, further characterized in that each said second component transmission equalization reference signal comprises a pseudo-noise (PN) sequence of a prescribed first length.

35. A receiver comprising:

circuitry for recovering a digitized baseband signal by detecting a television signal having a succession of frames, each of said frames comprising an odd-numbered field followed by an even-numbered field, each of said fields comprising a specified number of lines only a particular one of which said lines is designated for carrying a respective ghost-cancellation reference signal comprising a first component ghost-cancellation reference signal and a second component ghost-cancellation reference signal, said first component ghost-cancellation reference signals being of the same amplitude and sense of polarity in both said odd-numbered field and said even-numbered field of each said frame, said second component ghost-cancellation reference signals being the same in amplitude in both said odd-numbered field and said even-numbered field of each said frame but opposite in sense of polarity;

circuitry for separating from said digitized baseband signal said lines designated for carrying a ghost-cancellation reference signal;

memory for temporarily storing a number of said designated lines as separated;

combining circuitry for separating said second component ghost-cancellation reference signal from said designated lines by combining a most current one of said designated lines with at least one temporarily stored previous one of said designated lines;

an equalization filter with adjustable filtering weights, said equalization filter connected for responding to said digitized baseband signal; and

an equalization weight computer responding to said second component ghost-cancellation reference signal separated by said combining circuitry to determine said adjustable filtering weights of the equalization filter.

36. The receiver of claim 35, further characterized in that each said second component ghost-cancellation reference signal comprises a pseudo-noise (PN) sequence of a prescribed first length.

37. The receiver of claim 36, further characterized in that said combining circuitry is of a type for separating said pseudo-noise (PN) sequences of a prescribed first length from said ghost-cancellation reference signals by differentially combining said designated lines that are in the same frame.

38. The receiver of claim 35 further characterized in that, in each said particular one of said lines that is designated for carrying a respective ghost-cancellation reference signal, said second component ghost-cancellation reference signal is of shorter duration than said first component ghost-cancellation reference signal.

39. The receiver of claim 35 further characterized in that, in each said particular one of said lines that is designated for carrying a respective ghost-cancellation reference signal, said second component ghost-cancellation reference signal follows said first component ghost-cancellation reference signal.

40. The receiver of claim 31, further characterized in that each said second component ghost-cancellation reference signal comprises a pseudo-noise (PN) sequence of a prescribed first length.

41. The receiver of claim 40, further characterized in that said combining circuitry is of a type for separating said pseudo-noise (PN) sequences of said prescribed first length from said ghost-cancellation reference signals by differentially combining said designated lines that are in different fields of the same frame.

42. The receiver of claim 38, further characterized in that each said second component ghost-cancellation reference signal comprises a pseudo-noise (PN) sequence of a prescribed first length.

43. The receiver of claim 42, further characterized in that said combining circuitry is of a type for separating said pseudo-noise (PN) sequences of said prescribed first length from said ghost-cancellation reference signals by differentially combining said designated lines that are in different fields of the same frame.

44. The receiver of claim 35, further characterized in that said combining circuitry is of a type for separating said second component ghost-cancellation reference signals by combining an even number, at least four, of said designated lines.

45. The receiver of claim 44, further characterized in that each said second component ghost-cancellation reference signal comprises a pseudo-noise (PN) sequence of a prescribed first length.

46. The receiver of claim 44 further characterized in that, in each said particular one of said lines that is designated for carrying a respective ghost-cancellation reference signal, said second component ghost-cancellation reference signal is of shorter duration than said first component ghost-cancellation reference signal.

47. The receiver of claim 46 further characterized in that, in each said particular one of said lines that is designated for carrying a respective ghost-cancellation reference signal, said second component ghost-cancellation reference signal follows said first component ghost-cancellation reference signal.

48. The receiver of claim 47, further characterized in that each said second component ghost-cancellation reference signal comprises a pseudo-noise (PN) sequence of a prescribed first length.

49. A receiver comprising:

detection circuitry for recovering a digitized baseband signal by detecting a transmitted signal having a succession of frames, each of said frames comprising an odd-numbered field followed by an even-numbered field, each of said fields comprising a specified number of lines, a particular one of which said lines is designated for carrying a respective transmission equalization reference signal comprising a first component transmission equalization reference signal and a second

component transmission equalization reference signal of shorter duration than said first component transmission equalization reference signal;

separator circuitry for separating each of said first and second component transmission equalization reference signals from said digitized baseband signal;

a ghost cancellation filter and an equalization filter connected in cascade for responding to said digitized baseband signal, each filter having adjustable filtering weights; and

filter weight computation circuitry for determining said adjustable filtering weights of said ghost cancellation filter responsive to said first component transmission equalization reference signals separated by said separator circuitry, and for determining said adjustable filtering weights of said equalization filter responsive to said second component transmission equalization reference signals separated by said separator circuitry.

50. The receiver of claim **49**, further characterized in that said filter weight computation circuitry comprises:

a ghost cancellation filter weight computer responding to said first component transmission equalization reference signals separated by said separator circuitry to determine said adjustable filtering weights of said ghost cancellation filter; and

an equalization filter weight computer responding to said second component transmission equalization reference signals separated by said separator circuitry to determine said adjustable filtering weights of said equalization filter.

51. The receiver of claim **50**, further characterized in that said ghost cancellation filter weight computer is arranged to calculate a discrete Fourier transform (DFT) in response to said first component transmission equalization reference signals separated by said separator circuitry and determines said adjustable filtering weights of the ghost cancellation filter from that DFT.

52. The receiver of claim **49**, further characterized in that said separator circuitry is of a type for separating said first component transmission equalization reference signals by combining an even number at least four of said designated lines.

53. A receiver comprising:

detection circuitry for recovering a digitized baseband signal by detecting a transmitted signal having a succession of frames, each of said frames comprising an odd-numbered field followed by an even-numbered field, each of said fields comprising a specified number of lines, a particular one of which said lines is designated for carrying a respective transmission equalization reference signal comprising a first component transmission equalization reference signal and a second component transmission equalization reference signal of shorter duration than said first component transmission equalization reference signal, said first component transmission equalization reference signals being of the same amplitude and sense of polarity in both said odd-numbered field and said even-numbered field of each said frame, said second component transmission equalization reference signals being the same in amplitude in both said odd-numbered field and said even-numbered field of each said frame but opposite in sense of polarity;

circuitry for separating from said digitized baseband signal said lines designated for carrying a transmission equalization reference signal;

memory for temporarily storing a number of said designated lines as separated;

combining circuitry for separating from said transmission equalization reference signals said first component transmission equalization reference signal and said second component transmission equalization reference signal by combining a most current one of said designated lines with at least one temporarily stored previous one of said designated lines;

a ghost cancellation filter and an equalization filter connected in cascade for responding to said digitized baseband signal, each filter having adjustable filtering weights; and

filter weight computation circuitry for determining said adjustable filtering weights of said ghost cancellation filter responsive to said first component transmission equalization reference signals separated by said combining circuitry, and for determining said adjustable filtering weights of said equalization filter responsive to said second component transmission equalization reference signals separated by said combining circuitry.

54. The receiver of claim **53**, further characterized in that said filter weight computation circuitry comprises:

a ghost cancellation filter weight computer responding to said first component transmission equalization reference signals separated by said combining circuitry to determine said adjustable filtering weights of said ghost cancellation filter; and

an equalization filter weight computer responding to said second component transmission equalization reference signals separated by said combining circuitry to determine said adjustable filtering weights of said equalization filter.

55. The receiver of claim **54**, further characterized in that said ghost cancellation filter weight computer is arranged to calculate a discrete Fourier transform (DFT) in response to said first component transmission equalization reference signals separated by said combining circuitry and determines said adjustable filtering weights of the ghost cancellation filter from that DFT.

56. The receiver of claim **53**, further characterized in that said combining circuitry is of a type for separating said first component transmission equalization reference signals and said second component transmission equalization reference signals by combining an even number, at least four, of said designated lines.

57. A receiver as set forth in claim **53**, further characterized in that in each of said transmission equalization reference signals said first component transmission equalization reference signal precedes said second component transmission equalization reference signal.

58. The receiver of claim **57**, further characterized in that said filter weight computation circuitry comprises:

a ghost cancellation filter weight computer responding to said first component transmission equalization reference signals separated by said combining circuitry to determine said adjustable filtering weights of said ghost cancellation filter; and

an equalization filter weight computer responding to said second component transmission equalization reference signals separated by said combining circuitry to determine said adjustable filtering weights of said equalization filter.

59. The receiver of claim **58**, further characterized in that said ghost cancellation filter weight computer responds to said first component transmission equalization reference

signals separated by said combining circuitry to calculate a discrete Fourier transform (DFT) therefrom and determines said adjustable filtering weights of the ghost cancellation filter from that DFT.

60. The receiver of claim 57, further characterized in that said combining circuitry is of a type for separating said first component transmission equalization reference signals and said second component transmission equalization reference signals by combining an even number, at least four, of said designated lines.

61. The receiver of claim 53, further characterized in that each said second component transmission equalization reference signal comprises a pseudo-noise (PN) sequence of a prescribed first length.

62. The receiver of claim 61, further characterized in that said filter weight computation circuitry comprises:

a ghost cancellation filter weight computer responding to said first component transmission equalization reference signals separated by said combining circuitry to determine said adjustable filtering weights of said ghost cancellation filter; and

an equalization filter weight computer responding to said second component transmission equalization reference signals separated by said combining circuitry to determine said adjustable filtering weights of said equalization filter.

63. The receiver of claim 62, further characterized in that said ghost cancellation filter weight computer responds to said first component transmission equalization reference signals separated by said combining circuitry to calculate a discrete Fourier transform (DFT) therefrom and determines said adjustable filtering weights of the ghost cancellation filter from that DFT.

64. The receiver of claim 61, further characterized in that said combining circuitry is of a type for separating said first component transmission equalization reference signals and said second component transmission equalization reference signals by combining an even number, at least four, of said designated lines.

65. A receiver comprising:

circuitry for recovering a digitized baseband signal by detecting a television signal having a succession of frames, each of said frames comprising an odd-numbered field followed by an even-numbered field, each of said fields comprising a specified number of lines with a particular one of said lines being designated to carry a respective ghost-cancellation reference signal comprising a first component ghost-cancellation reference signal and a second component ghost-cancellation reference signal of shorter duration than said first component ghost-cancellation reference signal;

separator circuitry for separating each of said first and second component ghost-cancellation reference signals from said digitized baseband signal;

a ghost cancellation filter and an equalization filter connected in cascade for responding to said digitized baseband signal, each filter having adjustable filtering weights; and

filter weight computation circuitry for determining said adjustable filtering weights of said ghost cancellation filter responsive to said first component ghost-cancellation reference signal separated by said separator circuitry, and for determining said adjustable filtering weights of said equalization filter responsive to said second component ghost-cancellation reference signal separated by said separator circuitry.

66. The receiver of claim 65, further characterized in that said filter weight computation circuitry comprises:

a ghost cancellation filter weight computer responding to said first component ghost-cancellation reference signals separated by said separator circuitry to determine said adjustable filtering weights of said ghost cancellation filter; and

an equalization filter weight computer responding to said second component ghost-cancellation reference signals separated by said separator circuitry to determine said adjustable filtering weights of said equalization filter.

67. The receiver of claim 66, further characterized in that said ghost cancellation filter weight computer is arranged to calculate a discrete Fourier transform (DFT) in response to said first component ghost-cancellation reference signal separated by said combing circuitry and determines said adjustable filtering weights of the ghost cancellation filter from that DFT.

68. A receiver comprising:

circuitry for recovering a digitized baseband signal by detecting a television signal having a succession of frames, each of said frames comprising an odd-numbered field followed by an even-numbered field, each of said fields comprising a specified number of lines with a particular one of said lines being designated to carry a respective ghost-cancellation reference signal comprising a first component ghost-cancellation reference signal and a second component ghost-cancellation reference signal of shorter duration than said first component ghost-cancellation reference signal, said first component ghost-cancellation reference signal being of the same amplitude and sense of polarity in both said odd-numbered field and said even-numbered field of each said frame, said second component ghost-cancellation reference signal being the same in amplitude in both said odd-numbered field and said even-numbered field of each said frame but opposite in sense of polarity;

circuitry for separating from said digitized baseband signal said lines designated for carrying a ghost-cancellation reference signal;

memory for temporarily storing a number of said designated lines as separated;

combining circuitry for separating from said ghost-cancellation reference signals said first component ghost-cancellation reference signal and said second component ghost-cancellation reference signal by combining a most current one of said designated lines with at least one temporarily stored previous one of said designated lines;

a ghost cancellation filter and an equalization filter connected in cascade for responding to said digitized baseband signal, each filter having adjustable filtering weights; and

filter weight computation circuitry, for determining said adjustable filtering weights of said ghost cancellation filter responsive to said first component ghost-cancellation reference signal separated by said separator circuitry, and for determining said adjustable filtering weights of said equalization filter responsive to said second component ghost-cancellation reference signal separated by said separator circuitry.

69. The receiver of claim 68, further characterized in that said filter weight computation circuitry comprises:

a ghost cancellation filter weight computer responding to said first component ghost-cancellation reference sig-

nals separated by said combining circuitry to determine said adjustable filtering weights of said ghost cancellation filter; and

an equalization filter weight computer responding to said second component ghost-cancellation reference signals separated by said combining circuitry to determine said adjustable filtering weights of said equalization filter.

70. The receiver of claim 69, further characterized in that said ghost cancellation filter weight computer is arranged to calculate a discrete Fourier transform (DFT) in response to said first component ghost-cancellation reference signal separated by said combing circuitry and determines said adjustable filtering weights of the ghost cancellation filter from that DFT.

71. The receiver of claim 68, further characterized in that said combining circuitry is of a type for separating said first component ghost-cancellation reference signals and said second component ghost-cancellation reference signals by combining an even number, at least four, of said designated lines.

72. A receiver as set forth in claim 68, further characterized in that in each of said ghost-cancellation reference signals said first component ghost-cancellation reference signal precedes said second component ghost-cancellation reference signal.

73. The receiver of claim 72, further characterized in that said filter weight computation circuitry comprises:

a ghost cancellation filter weight computer responding to said first component ghost-cancellation reference signals separated by said combining circuitry to determine said adjustable filtering weights of said ghost cancellation filter; and

an equalization filter weight computer responding to said second component ghost-cancellation reference signals separated by said combining circuitry to determine said adjustable filtering weights of said equalization filter.

74. The receiver of claim 73, further characterized in that said ghost cancellation filter weight computer responds to said first component ghost-cancellation reference signals separated by said combining circuitry to calculate a discrete Fourier transform (DFT) therefrom and determines said adjustable filtering weights of the ghost cancellation filter from that DFT.

75. The receiver of claim 72, further characterized in that said combining circuitry is of a type for separating said first component ghost-cancellation reference signals and said second component ghost-cancellation reference signals by combining an even number, at least four, of said designated lines.

76. The receiver of claim 68, further characterized in that each said second component ghost-cancellation reference signal comprises a pseudo-noise (PN) sequence of a prescribed first length.

77. The receiver of claim 76, further characterized in that said filter weight computation circuitry comprises:

a ghost cancellation filter weight computer responding to said first component ghost-cancellation reference signals separated by said combining circuitry to determine said adjustable filtering weights of said ghost cancellation filter; and

an equalization filter weight computer responding to said second component ghost-cancellation reference signals separated by said combining circuitry to determine said adjustable filtering weights of said equalization filter.

78. The receiver of claim 77, further characterized in that said ghost cancellation filter weight computer responds to said first component ghost-cancellation reference signals separated by said combining circuitry to calculate a discrete Fourier transform (DFT) therefrom and determines said adjustable filtering weights of the ghost cancellation filter from that DFT.

79. The receiver of claim 76, further characterized in that said combining circuitry is of a type for separating said first component ghost-cancellation reference signals and said second component ghost-cancellation reference signals by combining an even number, at least four, of said designated lines.

80. A television receiver for detecting and processing television signals transmitted in a succession of frames, each of said frames comprising an odd-numbered field followed by an even-numbered field, each of said fields comprising a specified number of line s with at least one of said lines being designated to carry a ghost-cancellation reference signal comprising a first component ghost-cancellation reference signal and a second component ghost-cancellation reference signal, said television receiver comprising:

an input for collecting said television signals, wherein said television signals include video signals and said ghost-cancellation reference signals;

an analog to digital converter coupled to said input for digitizing said video signals and said ghost-cancellation reference signals collected by said input;

a signal capture processor coupled to said analog to digital converter for receiving said digitized ghost-cancellation reference signals and for separating said first component ghost-cancellation reference signal from said second component ghost-cancellation reference signal;

a ghost-cancellation filter weight computer coupled to said signal capture processor for receiving said first component ghost-cancellation reference signal and for responding to said first component ghost-cancellation reference signal to determine a first set of adjustable filtering weights; and

an adjustable ghost-cancellation filter coupled to said analog to digital converter for receiving said digitized video signals and also coupled to said ghost-cancellation filter weight computer for receiving said first set of adjustable filtering weights, said adjustable ghost-cancellation filter processing said digitized video signals in response to said first set of adjustable filtering weights.

81. The television receiver of claim 80 further comprising:

an equalization filter weight computer coupled to said signal capture processor for receiving said second component ghost-cancellation reference signal and for responding to said second component ghost-cancellation reference signal to determine a second set of adjustable filtering weights; and

an adjustable equalization filter coupled in cascade with said adjustable ghost cancellation filter and also coupled to said equalization filter weight computer for receiving said second set of adjustable filtering weights, said adjustable equalization filter processing signals output by said adjustable ghost cancellation filter in response to said second set of adjustable filtering weights.

82. The television receiver of claim 80 further characterized in that said second component ghost-cancellation reference signal is of shorter duration than said first component ghost-cancellation reference signal.

83. The television receiver of claim 82 further characterized in that said second component ghost-cancellation reference signal is a pseudo-noise (PN) sequence.

84. The television receiver of claim 83 further characterized in that said first component ghost-cancellation reference signal is of the same amplitude and sense of polarity in both said odd-numbered field and said even-numbered field of each said frame, and said second component ghost-cancellation reference signal is the same in amplitude in both said odd numbered field and said even-numbered field of each said frame but opposite in sense of polarity.

85. The television receiver of claim 84 further comprising:

an equalization filter weight computer coupled to said signal capture processor for receiving said second component ghost-cancellation reference signal and for responding to said second component ghost-cancellation reference signal to determine a second set of adjustable filtering weights; and

an adjustable equalization filter coupled in cascade with said adjustable ghost cancellation filter and also coupled to said equalization filter weight computer for receiving said second set of adjustable filtering weights, said adjustable equalization filter processing signals output by said adjustable ghost cancellation filter in response to said second set of adjustable filtering weights.

86. A television receiver for detecting and processing television signals transmitted in a succession of frames, each of said frames comprising an odd-numbered field followed by an even-numbered field, each of said fields comprising a specified number of line with at least one of said lines being designated to carry a ghost-cancellation reference signal comprising a first component ghost-cancellation reference signal and a second component ghost-cancellation reference signal, said television receiver comprising:

an analog-to-digital converter for digitizing said analog baseband signal to generate a digital baseband signal including digitized ghost-cancellation reference signals;

adaptive digital filtering circuitry with adjustable filtering weights, said adaptive digital filtering circuitry connected for receiving as an input signal thereof said digital baseband signal as supplied from said analog-to-digital converter with any accompanying multi-path distortion and for supplying as an output signal therefrom said digital baseband signal with reduction of any accompanying multi-path distortion;

a signal capture processor connected for receiving said digital baseband signal from said analog-to-digital converter, for retrieving said first component ghost-cancellation reference signal from said digital baseband signal, and for retrieving said second component ghost-cancellation reference signal from said digital baseband signal; and

filter weight computation circuitry, for determining said adjustable filtering weights of said adaptive digital filtering circuitry responsive to at least one of said first and said second component ghost-cancellation reference signals.

87. The television receiver of claim 86, wherein said adaptive digital filtering circuitry comprises the cascade connection of:

a first adaptive digital filter; and

a second adaptive digital filter, said first adaptive digital filter having a first set of said adjustable filtering weights; and wherein said filter weight computation circuitry is of a type for determining said first set of said adjustable filtering weights responsive to said first component ghost-cancellation reference signal.

88. The television receiver of claim 87, wherein said first adaptive digital filter is operable as a ghost-cancellation filter.

89. The television receiver of claim 87, wherein said second adaptive digital filter has a second set of said adjustable filtering weights; and wherein said filter weight computation circuitry is of a type for determining said second set of said adjustable filtering weights responsive to said second component ghost-cancellation reference signal.

90. The television receiver of claim 89, wherein said first adaptive digital filter is operable as a ghost-cancellation filter and said second adaptive digital filter is operable as an equalization filter.

91. The television receiver of claim 90, wherein said first adaptive digital filter precedes said second adaptive digital filter in their said cascade connection.

92. The television receiver of claim 90, wherein said second component ghost-cancellation reference signal is of shorter duration than said first component ghost-cancellation reference signal.

93. The television receiver of claim 90, wherein said second component ghost-cancellation reference signal is a pseudo-noise (PN) sequence.

94. The television receiver of claim 90, wherein said first component ghost-cancellation reference signal is of the same amplitude and sense of polarity in both said odd-numbered field and said even-numbered field of each said frame, and said second component ghost-cancellation reference signal is the same in amplitude in both said odd-numbered field and said even-numbered field of each said frame but opposite in sense of polarity.

95. The television receiver of claim 86, wherein said adaptive digital filtering comprises the cascade connection of:

a first adaptive digital filter; and

a second adaptive digital filter, said second adaptive digital filter having a respective set of said adjustable filtering weights; and wherein said filter weight computation circuitry is of a type for determining said adjustable filtering weights of said second adaptive digital filter responsive to said second component ghost-cancellation reference signal.

96. The television receiver of claim 95, wherein said second adaptive digital filter is operable as an equalization filter.

97. The television receiver of claim 96, wherein said first adaptive digital filter precedes said second adaptive filter in their said cascade connection.

98. A receiver comprising:

detection circuitry for recovering a digitized baseband signal by detecting a transmitted signal having a succession of frames, each of said frames comprising an odd-numbered field followed by an even-numbered field, each of said fields comprising a specified number of lines with only a particular one of said lines being designated to carry a respective transmission equalization reference signal comprising a first component transmission equalization reference signal and a second component transmission equalization reference signal, said first component transmission equalization reference signals being of the same amplitude and sense of polarity in both said odd-numbered field and said even-numbered field of each said frame, said second

component transmission equalization reference signals being pseudo-noise (PN) sequences and being the same in amplitude in both said odd-numbered field and said even-numbered field of each said frame but opposite in sense of polarity;

circuitry for separating from said digitized baseband signal said lines designated for carrying a respective transmission equalization reference signal;

retrieving circuitry for retrieving either of said first component or second component transmission equalization reference signal from said lines designated for carrying said respective transmission equalization reference signal;

an equalization filter with adjustable filtering weights, said equalization filter connected for responding to said digitized baseband signal; and

an equalization weight computer responding to either of said first component or said second component transmission equalization reference signal retrieved by said retrieving circuitry to determine said adjustable filtering weights of the equalization filter.

99. A receiver comprising:

circuitry for recovering a digitized baseband signal by detecting a television signal having a succession of frames, each of said frames comprising an odd-numbered field followed by an even-numbered field, each of said fields comprising a specified number of lines only a particular one of which said lines is designated for carrying a respective ghost-cancellation reference signal comprising a first component ghost-cancellation reference signal and a second component ghost-cancellation reference signal, said first component ghost-cancellation reference signals being of the same amplitude and sense of polarity in both said odd-numbered field and said even-numbered field of each said frame, said second component ghost-cancellation reference signals being pseudo-noise (PN) sequences and being the same in amplitude in both said odd-numbered field and said even-numbered field of each said frame but opposite in sense of polarity;

circuitry for separating from said digitized baseband signal said lines designated for carrying a ghost-cancellation reference signal;

retrieving circuitry for retrieving either of said first component or said second component ghost-cancellation reference signal from said lines designated for carrying said ghost-cancellation reference signal;

an equalization filter with adjustable filtering weights, said equalization filter connected for responding to said digitized baseband signal; and

an equalization weight computer responding to either of said first component or said second component ghost-cancellation reference signal retrieved by said retrieving circuitry to determine said adjustable filtering weights of the equalization filter.

100. A television receiver for detecting and processing television signals transmitted in a succession of frames, each of said frames comprising an odd-numbered field followed by an even-numbered field, each of said fields comprising a specified number of lines with at least one of said lines being designated to carry a ghost-cancellation reference signal comprising a first component ghost-cancellation reference signal and a second component ghost-cancellation reference signal, said television receiver comprising:

an input for collecting said television signals, wherein said television signals include video signals and said ghost-cancellation reference signals;

an analog to digital converter coupled to said input for digitizing said video signals and said ghost-cancellation reference signals collected by said input;

a signal capture processor coupled to said analog to digital converter for receiving said digitized ghost-cancellation reference signals and for retrieving said first component ghost-cancellation reference signal from said designated one of said lines;

a ghost-cancellation filter weight computer coupled to said signal capture processor for receiving said first component ghost-cancellation reference signal and for responding to said first component ghost-cancellation reference signal to determine a first set of adjustable filtering weights; and

an adjustable ghost-cancellation filter coupled to said analog to digital converter for receiving said digitized video signals and also coupled to said ghost-cancellation filter weight computer for receiving said first set of adjustable filtering weights, said adjustable ghost-cancellation filter processing said digitized video signals in response to said first set of adjustable filtering weights.

101. The television receiver of claim **100** further characterized in that said second component ghost-cancellation reference signal is of shorter duration than said first component ghost-cancellation reference signal.

102. The television receiver of claim **101** further characterized in that said second component ghost-cancellation reference signal is a pseudo-noise (PN) sequence.

103. The television receiver of claim **102** further characterized in that said first component ghost-cancellation reference signal is of the same amplitude and sense of polarity in both said odd-numbered field and said even-numbered field of each said frame, and said second component ghost-cancellation reference signal is the same in amplitude in both said odd-numbered field and said even-numbered field of each said frame but opposite in sense of polarity.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,184,938 B1
DATED : February 6, 2001
INVENTOR(S) : Patel, et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 9,
Line 7, replace "42" with -- 92 --.
Line 16, replace "11A, 11B, 11C and 11D" with -- 1A, 1B, 1C and 1D --.

Claim 40,
Line 13, replace "31" with -- 39 --.

Claim 80,
Line 16, replace "line s" with -- lines --.

Claim 84,
Line 10, replace "odd numbered" with -- odd-numbered --.

Claim 86,
Line 32, replace "line" with -- lines --.

Signed and Sealed this

Sixteenth Day of October, 2001

Attest:

Nicholas P. Godici

NICHOLAS P. GODICI

Attesting Officer

Acting Director of the United States Patent and Trademark Office

EXHIBIT 2

US006480239B1

(12) **United States Patent**
Patel et al.

(10) **Patent No.: US 6,480,239 B1**
(45) **Date of Patent: Nov. 12, 2002**

(54) **GHOST CANCELLATION REFERENCE SIGNAL WITH BESSEL CHIRPS AND PN SEQUENCES, AND TV RECEIVER USING SUCH SIGNAL**

(75) Inventors: **Chandrakant Bhailalbhai Patel**, Hopewell, NJ (US); **Jian Yang**, Bensalem, PA (US)

(73) Assignee: **Samsung Electronics Co., Ltd.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/575,259**

(22) Filed: **May 19, 2000**

Related U.S. Application Data

(63) Continuation of application No. 09/246,182, filed on Feb. 4, 1999, now Pat. No. 6,184,938, which is a division of application No. 08/158,299, filed on Nov. 29, 1993, which is a continuation-in-part of application No. 07/872,077, filed on Apr. 22, 1992, now abandoned, and a continuation-in-part of application No. 07/984,488, filed on Dec. 2, 1992, now abandoned.

(51) **Int. Cl.**[7] **H04N 5/21**
(52) **U.S. Cl.** **348/614**
(58) **Field of Search** 348/614, 608; H04N 5/21

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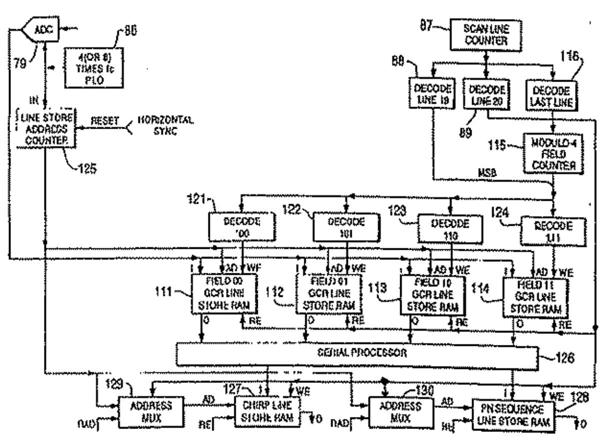
Primary Examiner—Michael H. Lee
(74) *Attorney, Agent, or Firm*—Jae Nam Nah; Michael S. Dowler; Howrey Simon Arnold & White, LLP

(57) **ABSTRACT**

Composite ghost cancellation reference (GCR) signals that make available both a chirp and a PN sequence during the same vertical-blanking-interval (VBI) scan line in each successive field facilitate more rapid and efficient calculations of ghost cancellation and of equalization, on a continuing basis. A television receiver for use with such composite GCR signals includes circuitry for separating the chirp and PN sequence portions of the GCR signals from the remainder of the composite video signal, a ghost cancellation filter and an equalization filter connected in cascade to respond to the composite video signal and provided each with adjustable filtering weights, and a computer. Random-access memory addressed during writing snatches the vertical-blanking-interval scan lines selected to include GCR signals. Sets of four successive ones of the selected scan lines are then additively and subtractively combined to separate the chirp portions of the GCR signals from a remainder of the composite video signal. The sets of selected scan lines are additively and subtractively combined in another way to separate the PN sequence portions of the GCR signals form a remainder of the composite video signal. The computer responds to the separated chirp portions of the GCR signals to calculate a discrete Fourier transform (DFT) therefrom. The computer proceeds from that DFT to determine the adjustable filtering weights of the ghost cancellation filter. The computer thereafter responds to the separated PN sequences to determine the adjustable filtering weights of the equalization filter.

21 Claims, 6 Drawing Sheets



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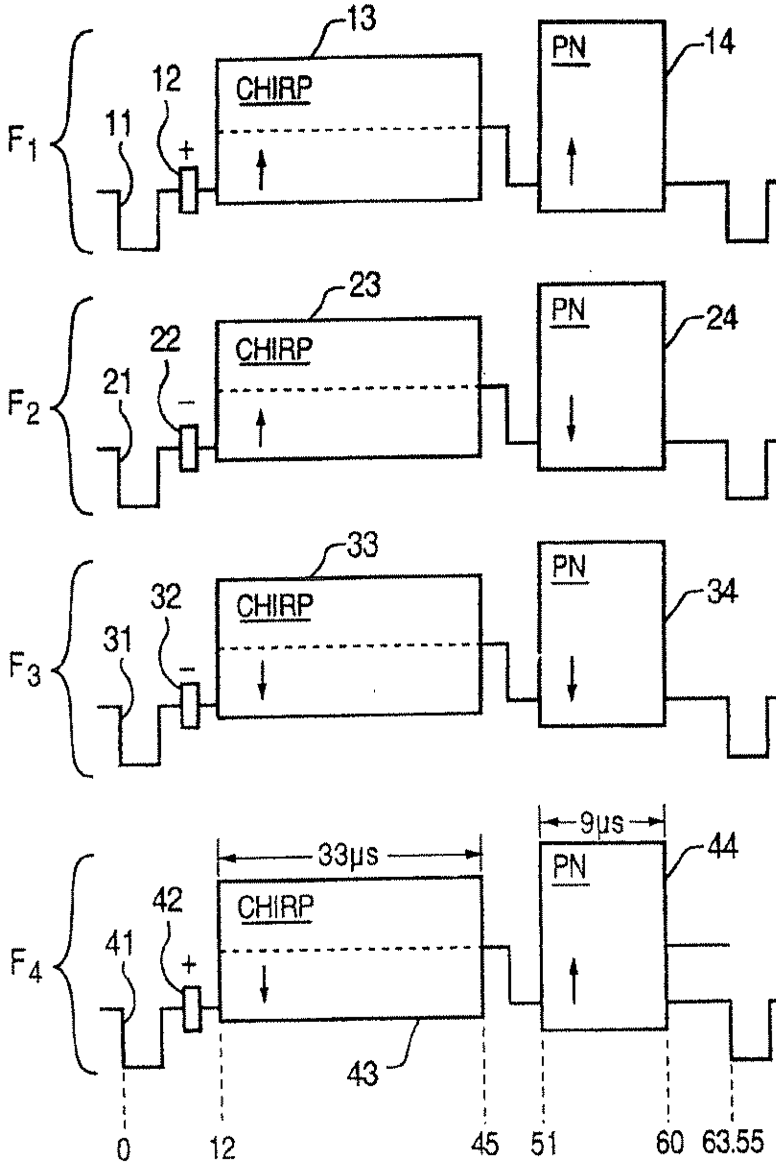


Fig. 1A

Fig. 1B

Fig. 1C

Fig. 1D

Fig. 2

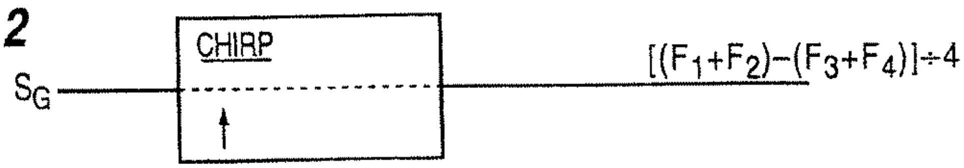
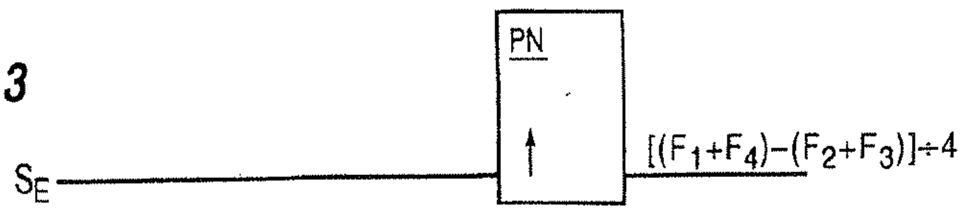


Fig. 3



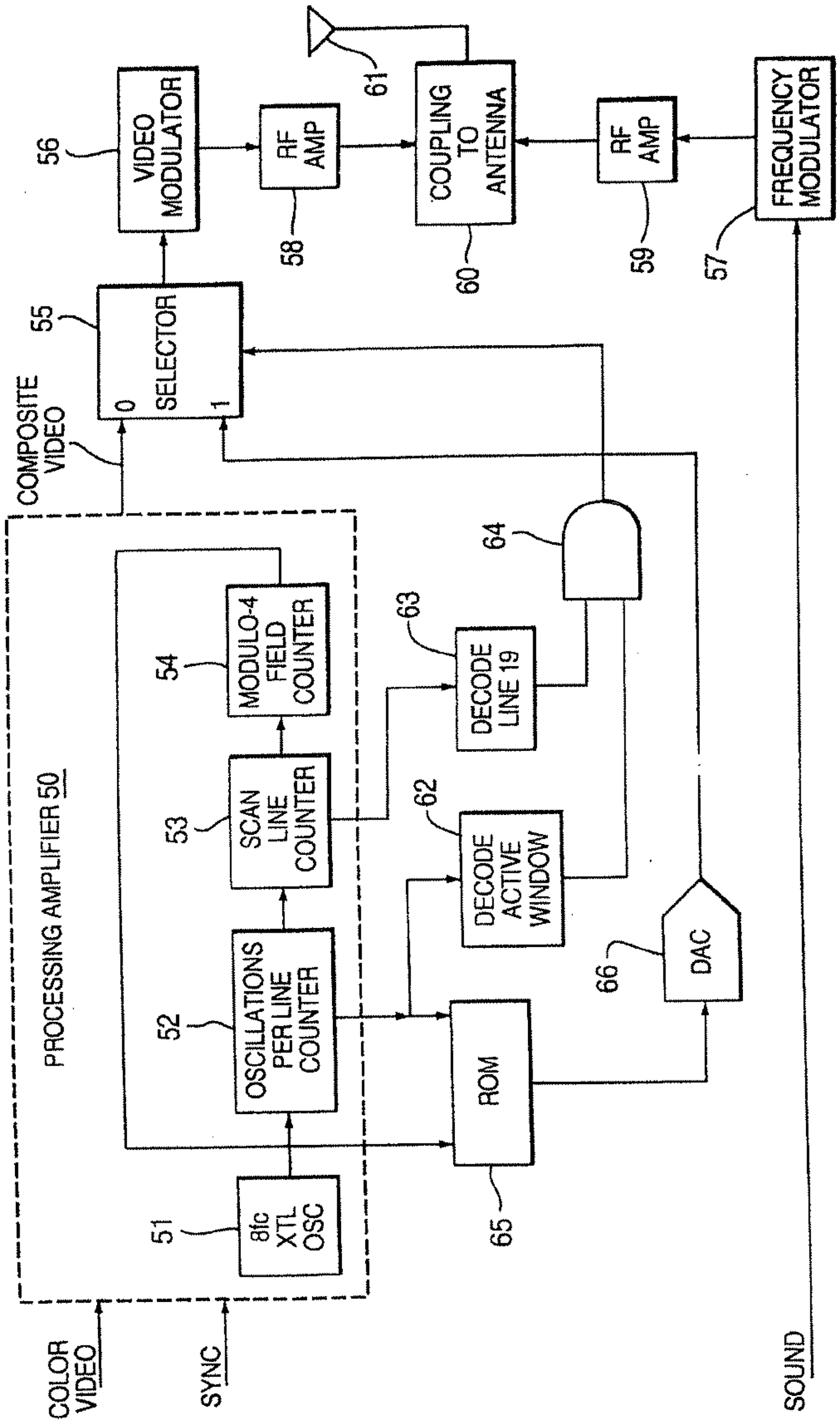

COLOR VIDEO
SYNC
SOUND
PROCESSING AMPLIFIER 50
51
8fc XTL OSC
52
OSCILLATIONS PER LINE COUNTER
53
SCAN LINE COUNTER
54
MODULO-4 FIELD COUNTER
COMPOSITE VIDEO
55
SELECTOR
0
1
56
VIDEO MODULATOR
58
RF AMP
61
60
COUPLING TO ANTENNA
59
RF AMP
57
FREQUENCY MODULATOR
63
DECODE LINE 19
62
DECODE ACTIVE WINDOW
64
65
ROM
66
DAC

Fig. 4

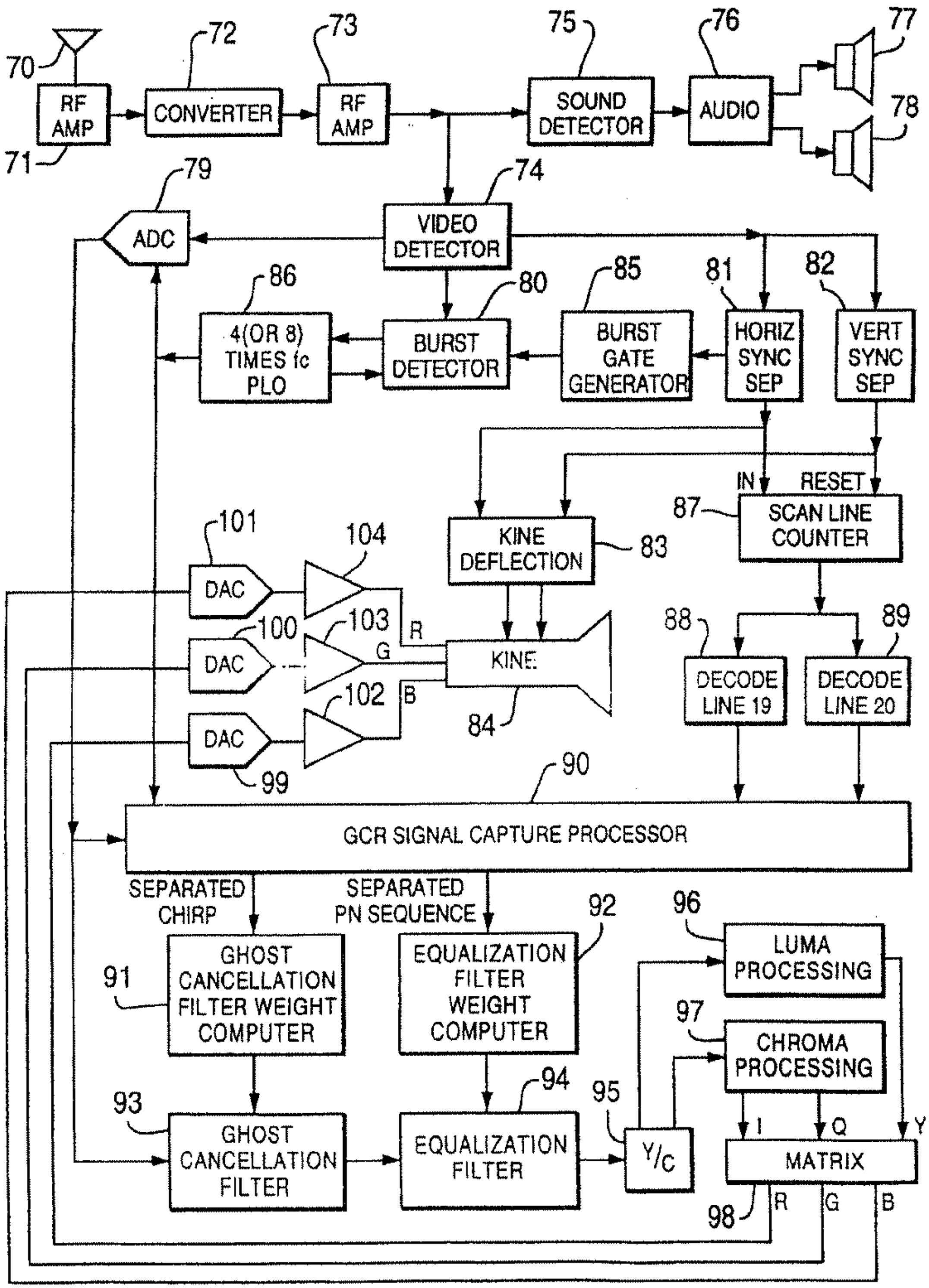
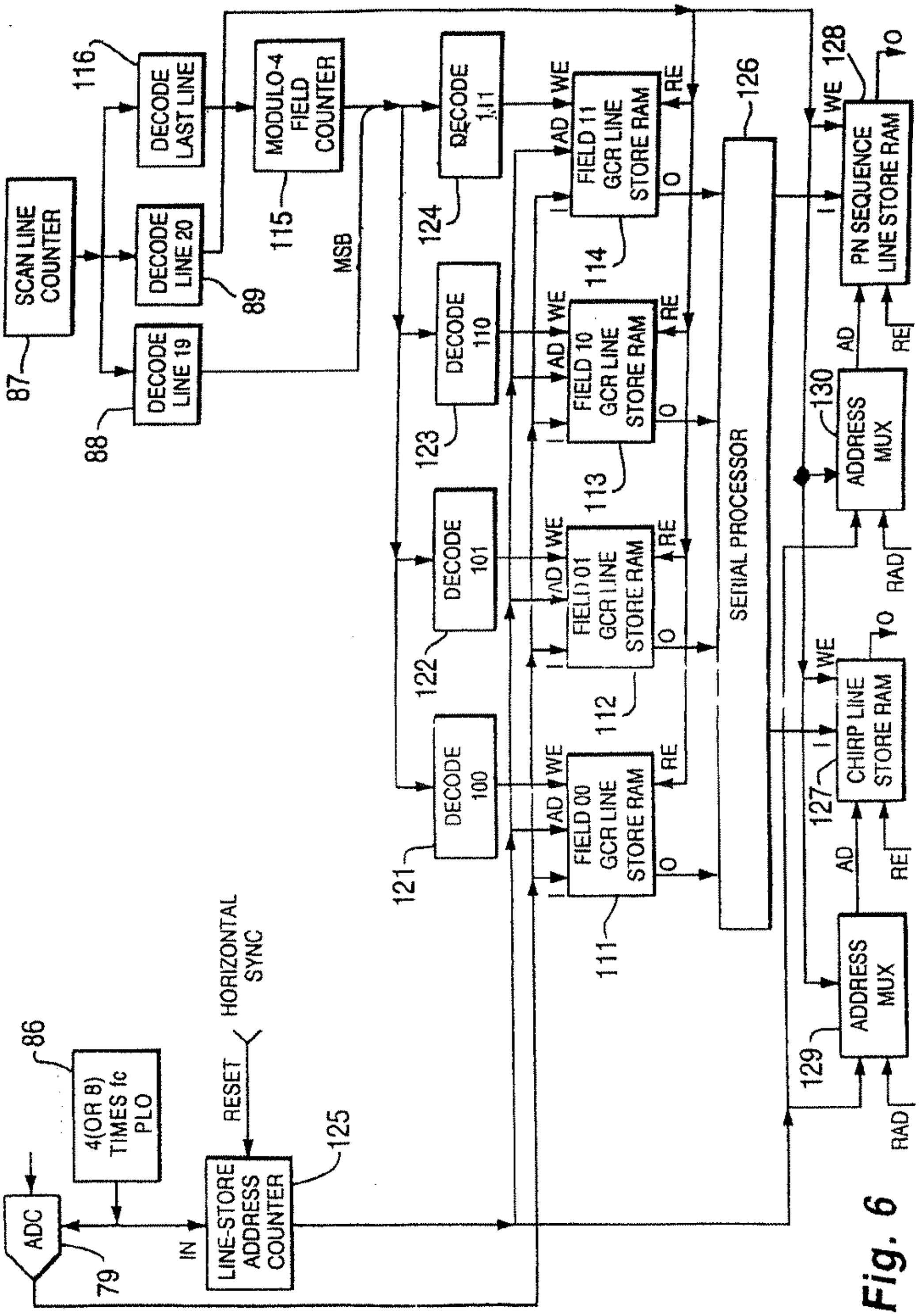

70
71
RF AMP
72
CONVERTER
73
RF AMP
75
SOUND DETECTOR
76
AUDIO
77
78
79
ADC
74
VIDEO DETECTOR
86
4(OR 8) TIMES fc PLO
80
BURST DETECTOR
85
BURST GATE GENERATOR
81
HORIZ SYNC SEP
82
VERT SYNC SEP
IN
RESET
87
SCAN LINE COUNTER
KINE DEFLECTION
83
101
DAC
104
100
DAC
103
R
G
B
KINE
102
DAC
99
84
88
89
DECODE LINE 19
DECODE LINE 20
90
GCR SIGNAL CAPTURE PROCESSOR
SEPARATED CHIRP
SEPARATED PN SEQUENCE
92
96
LUMA PROCESSING
91
GHOST CANCELLATION FILTER WEIGHT COMPUTER
EQUALIZATION FILTER WEIGHT COMPUTER
97
CHROMA PROCESSING
93
94
95
I
Q
Y
GHOST CANCELLATION FILTER
EQUALIZATION FILTER
Y/C
MATRIX
98
R
G
B

Fig. 5


SCAN LINE COUNTER
87
DECODE LINE 19
88
DECODE LINE 20
89
DECODE LAST LINE
116
MODULO-4 FIELD COUNTER
115
MSB
DECODE 111
124
DECODE 110
123
DECODE 101
122
DECODE 100
121
FIELD 11 GCR LINE STORE RAM
114
FIELD 10 GCR LINE STORE RAM
113
FIELD 01 GCR LINE STORE RAM
112
FIELD 00 GCR LINE STORE RAM
111
AD
WE
RE
I
O
SERIAL PROCESSOR
126
PN SEQUENCE LINE STORE RAM
128
ADDRESS MUX
130
CHIRP LINE STORE RAM
127
ADDRESS MUX
129
RAD
ADC
79
4(OR 8) TIMES fc PLO
86
LINE-STORE ADDRESS COUNTER
125
IN
RESET
HORIZONTAL SYNC
Fig. 6

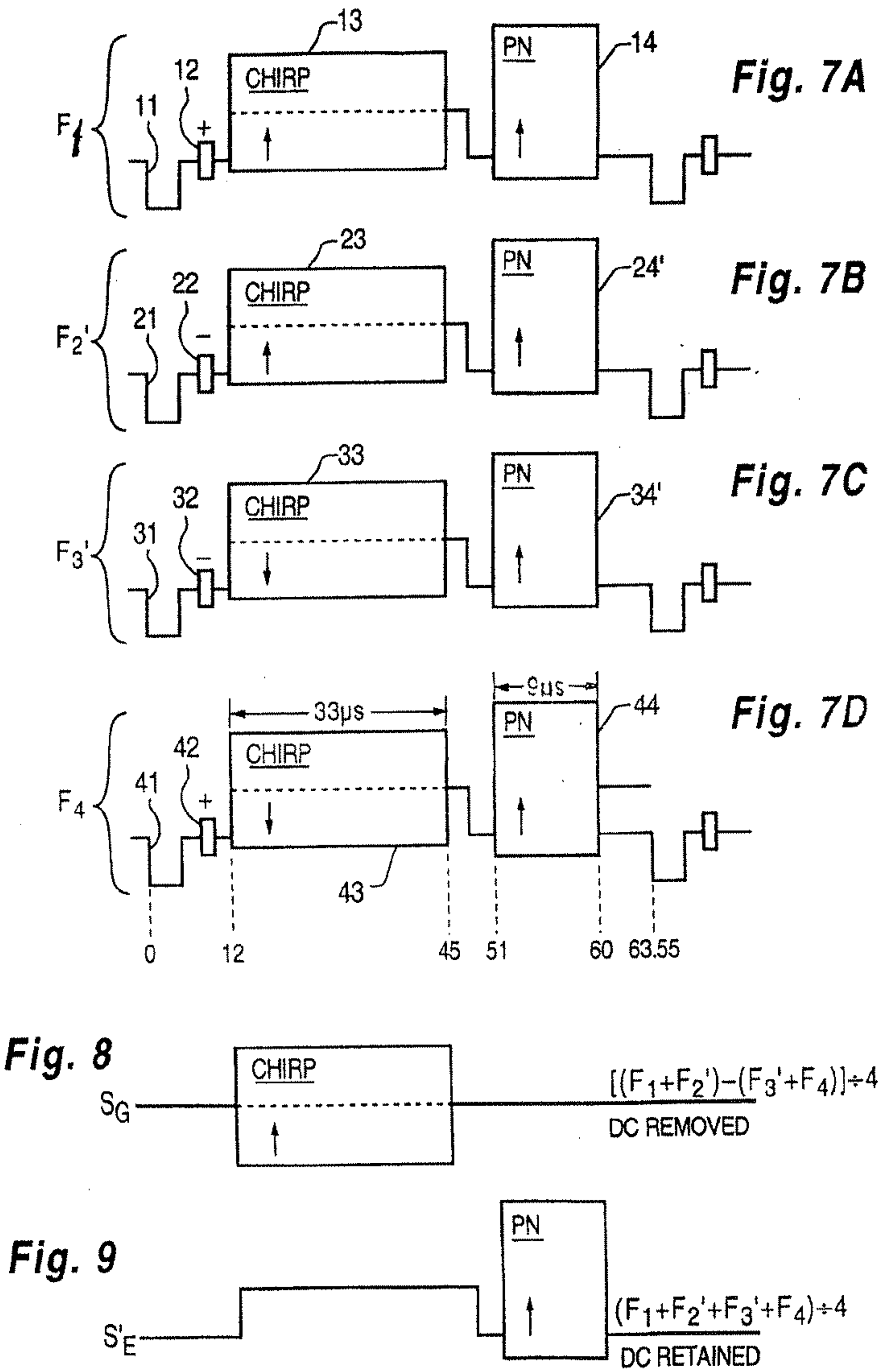


Fig. 7A
Fig. 7B
Fig. 7C
Fig. 7D
F1
F2'
F3'
F4
CHIRP
PN
11
12
13
14
21
22
23
24'
31
32
33
34'
41
42
43
44
+
−
33μs
9μs
0
12
45
51
60
63.55
Fig. 8
SG
[(F1+F2')−(F3'+F4)]÷4
DC REMOVED
Fig. 9
S'E
(F1+F2'+F3'+F4)÷4
DC RETAINED

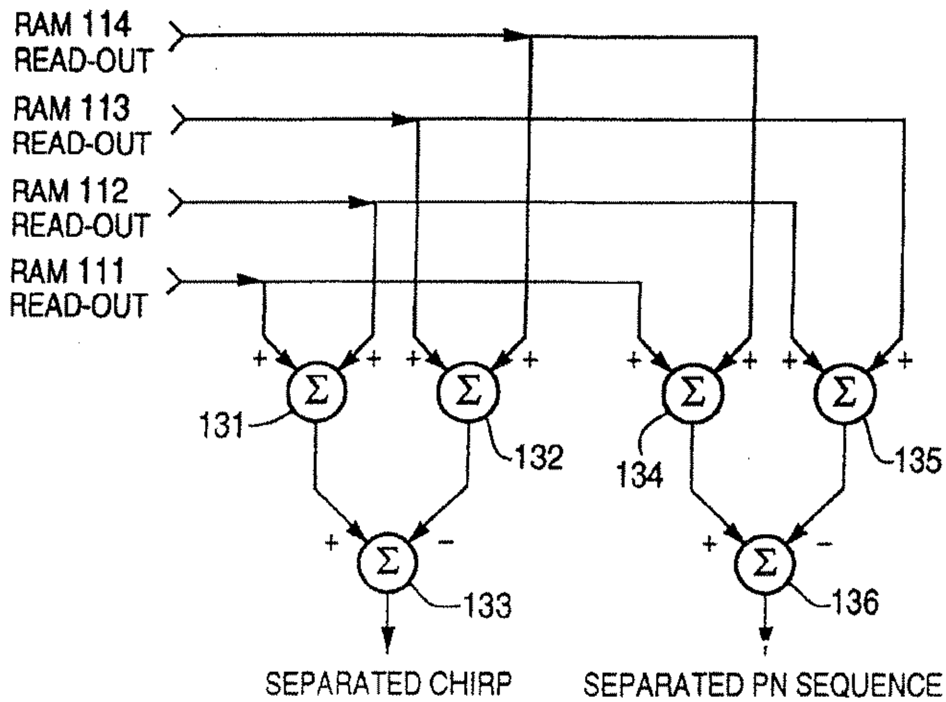

RAM 114
READ-OUT
RAM 113
READ-OUT
RAM 112
READ-OUT
RAM 111
READ-OUT
131
132
133
134
135
136
SEPARATED CHIRP
SEPARATED PN SEQUENCE

Fig. 10

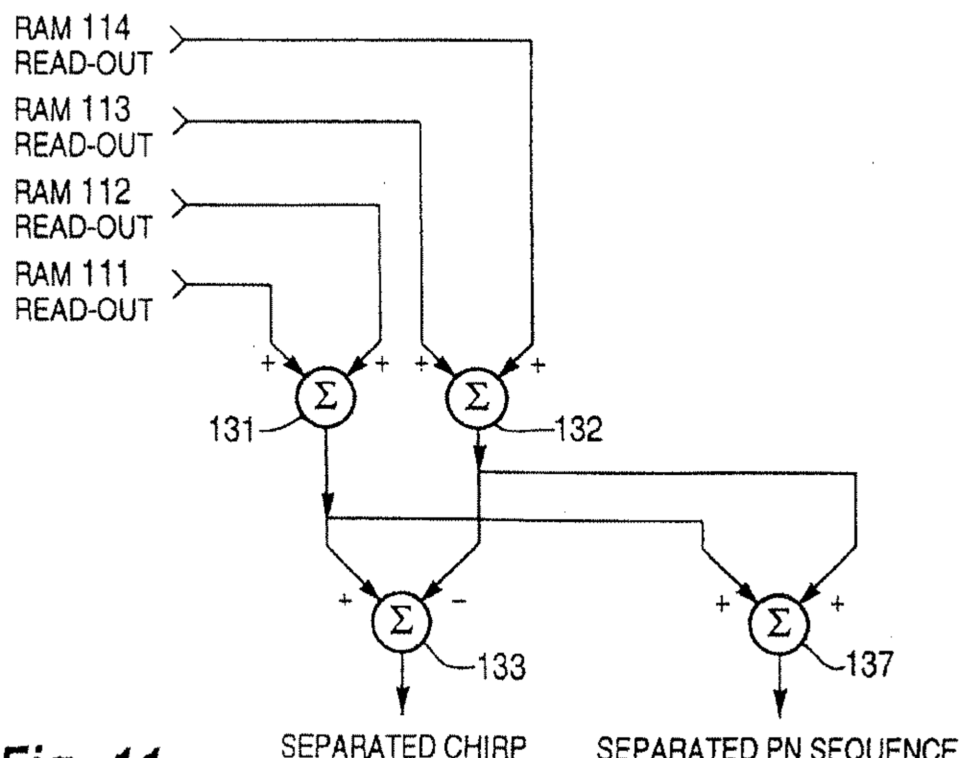

RAM 114
READ-OUT
RAM 113
READ-OUT
RAM 112
READ-OUT
RAM 111
READ-OUT
131
132
133
137
SEPARATED CHIRP
SEPARATED PN SEQUENCE

Fig. 11

GHOST CANCELLATION REFERENCE SIGNAL WITH BESSEL CHIRPS AND PN SEQUENCES, AND TV RECEIVER USING SUCH SIGNAL

This is a continuation of application Ser. No. 09/246,182, filed Feb. 4, 1999, now U.S. Pat. No. 6,184,938, which is a divisional of application Ser. No. 08/158,299, filed Nov. 29, 1993, which is a continuation-in-part of applications Ser. No. 07/872,077 filed Apr. 22, 1992, now abandoned, and Ser. No. 07/984,488 filed Dec. 2, 1992, now abandoned.

The invention relates to ghost cancellation reference (GCR) signals for use in a television receiver and to a television receiver employing those GCR signals.

BACKGROUND OF THE INVENTION

At the time U.S. patent application Ser. No. 07/872,077 was filed Subcommittee T-3 of the Advanced Television Systems Committee was meeting to determine a GCR signal for use in the United States. The GCR signal was to be a compromise based from two GCR signals, one using Bessel pulse chirp signals as proposed by U.S. Philips Corp. and one using pseudo noise (PN) sequences as proposed by the David Sarnoff Research Center (DSRC) of Stanford Research Institute. The GCR signals are inserted into selected vertical blanking intervals (VBIs). The GCR signals are used in a television receiver for calculating the adjustable weighting coefficients of a ghost-cancellation filter through which the composite video signals from the video detector are passed to supply a response in which ghosts are suppressed. The weighting coefficients of this ghost-cancellation filter are adjusted so it has a filter characteristic complementary to that of the transmission medium giving rise to the ghosts. The GCR signals can be further used for calculating the adjustable weighting coefficients of an equalization filter connected in cascade with the ghost-cancellation filter, for providing an essentially flat frequency spectrum response over the complete transmission path through the transmitter vestigial-sideband amplitude-modulator, the transmission medium, the television receiver front-end and the cascaded ghost-cancellation and equalization filters.

In the conventional method for cancelling ghosts in a television receiver, the discrete Fourier transform (DFT) of the ghosted GCR signal is divided by the DFT of the non-ghosted GCR signal (which latter DFT is known at the receiver from prior agreement with the transmitter) to obtain as a quotient the DFT transform of the transmission medium giving rise to ghosting; and the inverse DFT of this quotient is then used to define the filter weighting coefficients of a compensating ghost-cancellation filter through which the ghosted composite video signal is passed to obtain a de-ghosted composite video signal. To implement the DFT procedure efficiently, in terms of hardware or of calculations required in software, an integral power of two equal-bandwidth frequency bins are used in the DFT. The distribution of energy in the Philips chirp signal has a frequency spectrum extending continuously across the composite video signal band, in contrast to the DSRC PN sequence in which the distribution of energy does not extend continuously across the composite video signal band, but exhibits nulls in its frequency distribution. Accordingly, when the number of equal-bandwidth frequency bins in the DFT is reduced in order to speed calculation time, more accurate ghost cancellation is obtained with the chirp than with the PN sequence as GCR signal, the inventors observe.

During official testing by the Subcommittee, the DSRC GCR signal has exhibited somewhat better performance in

regard to equalization of the passband after ghosting, which some experts including the Philips engineers, attribute to better filter hardware. Theoretically, equalization calculated over an entire active portion of the VBI, proceeding from the PN sequence, has an accuracy substantially the same as the accuracy available calculating equalization from the chirp signal. The entire length of the Philips chirp signal is needed to have the requisite information to implement equalization over the full composite video signal band. The PN sequence contains pulse transitions each of which transitions has substantially the entire frequency spectrum contained therein. The PN sequence contains many pulse transitions, each of which transitions has component frequencies extending over substantially the entire frequency spectrum. This property of the PN sequence, the inventors observe, permits the calculation of equalization taking samples at a prescribed sampling density only over a limited extent of the GCR signal. Taking samples over only a portion of the GCR signal causes some loss in the accuracy with which equalization can be calculated, particularly under poor signal-to-noise conditions. However, since the number of samples involved in the calculation of weighting coefficients for the equalization filter is reduced, there can be an appreciable increase in the speed with which equalization can be calculated, presuming the calculation is done using an iterative method such as least-mean-squares error reduction. Also, there is reduced complexity, in terms of hardware or of calculations required in software, with regard to calculating the equalization filter weighting coefficients.

At the time U.S. patent application Ser. No. 07/872,077 was filed the composite GCR signals comprised of chirps and PN sequence signals that had been proposed did not make available both a chirp and a PN sequence during the same VBI scan line. Subsequently, the Republic of China has adopted a standard GCR signal in which both a chirp and a PN sequence occur during a VBI scan line in each successive field.

SUMMARY OF THE INVENTION

The inventors observe that making both a chirp and a PN sequence available during each of selected VBI scan lines (e.g., a prescribed VBI scan line in each successive field, facilitates the more rapid and efficient calculations of ghost cancellation and of equalization, on a continuing basis, particularly when the transmission medium exhibits continual change—e.g., during the rapidly changing ghost conditions caused in over-the-air transmissions by overflying aircraft.

A television receiver embodying the invention in one of its aspects includes means for separating the chirp and PN sequence portions of the ghost cancellation reference (GCR) signal from the remainder of the composite video signal, a ghost cancellation filter and an equalization filter connected in cascade to respond to the composite video signal and provided each with adjustable filtering weights, means responding to the separated chirp portion of the GCR signal to calculate its discrete Fourier transform (DFT), means responding to that DFT to determine the adjustable filtering weights of the ghost cancellation filter, and means responding to the separated PN sequence to determine the adjustable filtering weights of the equalization filter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A, 1B, 1C and 1D are waveforms of the ghost cancellation reference signals in selected vertical blanking intervals of four successive fields of video, as embody the invention in one of its aspects.

FIG. 2 is the waveform of a separated chirp signal as formed by differentially combining the sum of the ghost cancellation reference signals of FIGS. 1A and 1B with the sum of the ghost cancellation reference signals of FIGS. 1C and 1D.

FIG. 3 is the waveform of a separated PN sequence as formed by differentially combining the sum of the ghost cancellation reference signals of FIGS. 1A and 1D with the sum of the ghost cancellation reference signals of FIGS. 1B and 1C.

FIG. 4 is a schematic diagram of a television modulator arranged for transmitting the signals of FIGS. 1A, 1B, 1C and 1D.

FIG. 5 is a schematic diagram of a television receiver arranged to receive television signals incorporating the ghost cancellation reference signals of FIGS. 1A, 1B, 1C and 1D, to a suppress ghosts accompanying those television signals and to equalize the transmission channel across the video bandwidth.

FIG. 6 is a schematic diagram of the GCR signal capture processor shown as a block in FIG. 5.

FIGS. 7A, 7B, 7C and 7D are waveforms of the ghost cancellation reference signals in selected vertical blanking intervals of four successive fields of video, as embody the invention in one of its aspects, alternative to the aspect of the invention illustrated by FIGS. 1A, 1B, 1C and 1D.

FIG. 8 is the waveform of a separated chirp signal as formed by combining the ghost cancellation reference signals of FIGS. 7B and 7C, of FIGS. 7D and 7A, or FIGS. 7A, 7B, 7C and 7D.

FIG. 9 is the waveform of a separated PN sequence preceded by a "gray" pedestal, as formed by combining the ghost cancellation reference signals of FIGS. 7A, 7B, 7C and 7D.

FIG. 10 is a schematic diagram of the FIG. 6 serial processor for processing the ghost cancellation reference signals of FIGS. 1A, 1B, 1C and 1D to generate FIG. 2 and FIG. 3 signals.

FIG. 11 is a schematic diagram of the FIG. 6 serial processor for processing the ghost cancellation reference signals of FIGS. 7A, 7B, 7C and 7D to generate the FIG. 8 and FIG. 9 signals.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

FIGS. 1A, 1B, 1C and 1D show the ghost cancellation reference signals in selected scan lines of the vertical blanking intervals of four successive fields of video. Insertion may be into any one (or more) of the 11th through 20th scan lines of each field, the present preference being to replace the vertical interval reference (VIR) signal currently used in the 19th scan line of each field. To simplify the description that follows, insertion of GCR signal into the 19th scan line of each field will be assumed by way of specific illustration.

The ghost cancellation reference signals of FIGS. 1A, 1B, 1C and 1D begin with horizontal synchronization pulses 11, 21, 31 and 41, respectively, which pulses are shown as being negative-going. The leading edges of the horizontal synchronization pulses are considered to be the beginning of VBI scan lines that are each of 63.55 microsecond duration in NTSC standard television signals. The horizontal synchronization pulses 11, 21, 31 and 41 are respectively followed during ensuing back-porch intervals by chroma bursts 12, 22, 32 and 42. The plus and minus signs near the chroma bursts 12, 22, 32 and 42 indicate their relative polarities respective to each other, per the NTSC standard.

Bessel pulse chirps 13, 23, 33 and 43 each of 33 microsecond duration begin 12 microseconds into the VBI scan lines of FIGS. 1A, 1B, 1C and 1D, respectively. The arrows associated with each of these chirps is indicative of its relative polarity with respect to the other chirps; chirp polarity is shown as alternating from frame to frame. These chirps swing plus/minus 40 IRE from 30 IRE "gray" pedestals which extend from 12 to 48 microseconds into these VBI lines. The gray level of the pedestals, the plus/minus swing of the chirps, the duration of the pedestals and the duration of the chirps have been specified to correspond as closely as possible to the Philips system that has been officially tested; and design variations were, at the time U.S. patent application Ser. No. 07/872,077 was filed, expected to occur should the compromise GCR signals described herein be adopted by the Subcommittee as their official recommendation for a standard.

Beginning at 51 microseconds into the VBI scan lines of FIGS. 1A, 1B, 1C and 1D 127-sample PN sequences 14, 24, 34 and 44 respectively occur. Each of the PN sequences 14, 24, 34 and 44 is of the same 9-microsecond duration as the others. The PN sequence in the final field of each frame is of opposite polarity from the PN sequence in the initial field of that frame and is of the same polarity as the PN sequence in the initial field of the next frame, as indicated by the arrows associated with respective ones of the PN sequences 14, 24, 34 and 44. These PN sequences have −1 and +1 values at −15 IRE and +95 IRE levels respectively. These PN sequences have been specified to correspond as closely as possible to the DSRC system that has been officially tested; and design variations were, at the time U.S. patent application Ser. No. 07/872,077 was filed, expected to occur should the compromise GCR signals described herein be adopted by the Subcommittee as their official recommendation for a standard.

There was, at the time U.S. patent application Ser. No. 07/872,077 was filed, opinion within the Subcommittee that the Bessel pulse chirp should be shortened to 17 microsecond duration so ghosts of up to 40 microsecond delay can be cancelled without the restriction that the VBI line following that containing the GCR signal having not to have information therein that changes from field to field. If the Bessel pulse chirp is shortened, the PN sequence could be made to be 255 pulse sample times, rather than 127 pulse sample times, in length. Adjustments to the compromise GCR signals described herein may be made so the swings of the Bessel pulse chirp and the PN sequence correspond, with suitable adjustment of the gray pedestal, if appropriate. The inventors favor the chirp swing being increased to extend over the range between the −15 IRE and +95 IRE levels and the gray pedestal being set at 40 IRE. The lesser range for the chirps was chosen by the Philips engineers for fear of overswing under some conditions, but the inventors believe that IF amplifier AGC will forestall such overswing. Extending the gray pedestal to the beginning of the PN sequence will then provide a signal that when low-pass filtered and subsequently gated during the mid-portion of the scan line will provide a level that is descriptive of 40 IRE level and can be used for automatic gain control of the composite video signal.

FIG. 2 shows the separated Bessel pulse chirp waveform that results when the GCR signals from two successive fields that are in two successive frames are differentially combined, assuming that the GCR signals are of the sort shown in FIGS. 1A, 1B, 1C and 1D. A separated Bessel pulse chirp waveform per FIG. 2 results when the GCR signals of FIGS. 1B and 1C are differentially combined. A

separated Bessel pulse chirp waveform per FIG. 2 also results when the GCR signals of FIGS. 1D and 1A are differentially combined. A separated Bessel pulse chirp waveform per FIG. 2 also results when the sum of the GCR signals of FIGS. 1A and 1B is differentially combined with the sum of GCR signals of FIGS. 1C and 1D.

FIG. 3 shows the waveform that results when the sum of the GCR signals of FIGS. 1A and 1D is differentially combined with he sum of GCR signals of FIGS. 1B and 1C. The Bessel pulse chirp waveform, the "gray" pedestal and the chroma burst are suppressed in this signal; and DC information concerning 0 IRE level is lost. The PN sequence is maintained as a separated PN sequence signal.

FIG. 4 shows in block schematic form a television transmitter for NTSC color television signals into which are inserted GCR signals per FIGS. 1A, 1B, 1C and 1D. A processing amplifier **50** generates composite video signals proceeding from color video signals and synchronizing signals. By way of example, the color video signals may be red (R), green (G) and blue (B) signals from a studio color camera and the synchronizing signals may be from a studio sync generator that also supplies synchronizing signals to the studio color camera. Alternatively, the color video signals may be from a remote location and the synchronizing signals furnished by a genlock connection. Or, if the local transmitter is a low-power transmitter re-broadcasting signals received over-the-air from a distant high-power transmitter, the color video signals may be generated by demodulating the received composite video signal and the synchronizing signals may be separated from the received composite video signal.

The processing amplifier **50** is shown as including a crystal oscillator **51** furnishing oscillations at eight times color carrier frequency f_c, a counter **52** for counting the number of these oscillations per horizontal scan line, a counter **53** for counting scan lines per field, and a counter **54** for counting modulo-four successive fields of video signal. The processing amplifier **50** supplies its composite video output signal as a first input signal to an analog selector switch **55**. The output signal from the analog selector switch **55** is supplied to a video modulator **56** to control the vestigial-sideband amplitude modulation of the video carrier. Sound signal is supplied to a frequency modulator **57**. The modulated video and sound carriers are amplified by radio-frequency amplifiers **58** and **59**, respectively, and the output signals from the amplifiers **58** and **59** are combined in a coupling network **60** to a broadcast antenna **60**. A number of cariants of the conventional television transmitter arrangements described in this and the previous paragraph are known to those familiar with television transmitter design.

The analog selector switch **55** corresponds to that previously known for inserting the vertical interval reference (VIR) signal. A decoder **62** detects those portions of the count from the counter **52** associated with the "active" portions of horizontal scan lines—i.e., the portions of horizontal scan lines exclusive of the horizontal blanking intervals—to generate a logic ONE. A decoder **63** responds to the scan line count from the counter **53** to decode the occurrence of the 19th scan line in each field and generate a logic ONE. An AND gate **64** responds to these logic ONEs occurring simultaneously to condition the analog selector switch **55** to select a second input signal for application to the video modulator **56**, rather than the composite video signal furnished from the processing amplifier **50** to the analog selector switch **55** as its first input signal. This second signal is not the VIR signal, however, but is in successive fields successive ones of the GCR signals depicted in FIGS. 1A, 1B, 1C and 1D (or, alternatively, in FIGS. 7A, 7B, 7C and 7D).

These GCR signals are stored in digitized form in a read-only memory **65**. A first portion of the address for the ROM **65** is supplied from the counter **54**, the modulo-four field count selecting which of the GCR signals depicted in FIGS. 1A, 1B, 1C and 1D is to be inserted in the current field. A second portion of the address for the ROM **65** is supplied from the counter **52** and scans the selected one of the GCR signals depicted in FIGS. 1A, 1B, 1C and 1D. The digitized GCR signal read from the ROM **65** is supplied to a digital-to-analog converter **66**. The resulting analog GCR signal is supplied as the second input signal to the analog selector switch **55** for insertion into the "active" portion of the 19th line of the field.

FIG. 5 depicts a television receiver arranged to receive television signals incorporating the ghost cancellation reference signals of FIGS. 1A; 1B, 1C and 1D. Television signals collected by an antenna **70** are amplified by a radio-frequency amplifier **71** and then down-converted to an intermediate frequency by a converter **72**. An intermediate-frequency amplifier **73** supplies to a video detector **74** and to a sound detector **75** amplified response to the intermediate-frequency signals from the converter **72**. The sound detector **75** demodulates the frequency-modulated sound carrier and supplies the resulting sound detection result to audio electronics **76**. The audio electronics **76**, which may include stereophonic sound detection circuitry, includes amplifiers for supplying amplified sound-descriptive electric signals to loudspeakers **77** and **78**.

The video detector **74** supplies analog composite video signal to an analog-to-digital converter **79**, to a burst detector **80**, to a horizontal sync separator **81** and to a vertical sync separator **82**. The separated horizontal synchronizing pulses from the horizontal sync separator **81** and the separated vertical synchronizing pulses from the vertical sync separator **82** are supplied to kinescope deflection circuitry **83**, which generates deflection signals for a kinescope **84**. A burst gate generator **85** generates a burst gate signal an appropriate interval after each horizontal sync pulse it is supplied from the horizontal sync separator **81**. This burst gate signal keys the burst detector **80** into operation during chroma burst interval. The burst detector **80** is included in a phase-locking loop for a phase-locked oscillator **86**. The phase-locked oscillator **86** oscillates at a frequency sufficiently high that the analog-to-digital converter **79** sampling the analog composite video signal from the video detector **74** once with each oscillation oversamples that signal. As is well-known, it is convenient from the standpoint of simpler digital hardware design that phase-locked oscillator **86** oscillate at a frequency that is an integral of two greater than the 3.58 MHz color subcarrier frequency. Sampling chroma signals four or eight times per cycle is preferred.

The separated horizontal sync pulses from the horizontal sync separator **81** are supplied to a scan line counter **87** for counting, the scan line count from which counter **87** is reset to zero at the outset of each vertical sync interval by separated vertical sync pulses from the vertical sync separator **82**. Indication in the count from the counter **87** of the occurrence of the 19th scan line in each field is detected by a decoder **88**. Indication in the count from the counter **87** of the occurrence of the 20th scan line in each field is detected by a decoder **89**. The occurrences of the 19th and 20th scan line in each field is signaled to a GCR signal capture processor **90**, which captures the GCR signals in the 19th scan line of each field of digital composite video signal from

the analog-to-digital converter 79. This capturing process will be described in greater detail in connection with the description of FIG. 6.

The GCR signal capture processor 90 includes circuitry for separating the Bessel pulse chirp portion of the captured GCR signals, which portion is supplied to a ghost-cancellation filter weight computer 91. The GCR signal capture processor 90 also includes circuitry for separating the PN sequence portion of the captured GCR signals, which portion is supplied to an equalization filter weight computer 92. The digitized composite video signal from the analog-to-digital converter 79 is supplied via a cascade connection of a ghost-cancellation filter 93 and an equalization filter 94 to a luma/chroma separator 95. The ghost-cancellation filter 93 has filtering weights adjustable in response to results of the computations by the ghost-cancellation filter weight computer 91, and the equalization filter 94 has filtering weights adjustable in response to results of the computations by the equalization filter weight computer 92.

The ghost-cancellation filter weight computer 91 is preferably of a type in which the discrete Fourier transform (DFT) of the ghosted GCR signal is divided by the DFT of the non-ghosted GCR signal to obtain as a quotient the DFT transform of the transmission medium giving rise to ghosting; and the inverse DFT of this quotient is then used to define the filter weighing coefficients of a compensating ghost-cancellation filter. As known by those skilled in the ghost-cancellation art, the ghost-cancellation filter 93 is preferably of a type with a sparse kernel where the positioning of the non-zero filter weights can be shifted responsive to results from the ghost-cancellation filter weight computer 91. A ghost-cancellation filter with a dense kernel would typically require 2048 filter weights, which would be difficult to construct in actual practice.

The equalization filter weight computer 92 could be of a type performing calculations using DFTs, the results of which are subject to inverse-DFT in order to define the filter weighing coefficients of a compensating equalization filter 94. Preferably, however, the equalization filter weight computer 92 is of a type using a least-mean-square error method to perform an interative adjustment of a 15-tap or so digital FIR filter used as the equalization filter 94, adjustment being made so that there is a best match to the (sin x)/x function of the result of correlating of a portion of the de-ghosted PN sequence with the corresponding portion of the PN sequence known at the receiver as being a standard.

The luma/chroma separator 95 is preferably of a type using digital comb filtering for separating a digital luminance signal and a digital chroma signal from each other, which signals are respectively supplied to digital luminance processing circuitry 96 and to digital chrominance processing circuitry 97. The digital luminance (Y) signal from the digital luminance processing circuitry 96 and the digital I and Q signals from the digital chrominance processing circuitry 97 are supplied to a digital color matrixing circuit 98. Matrixing circuit 98 responds to the digital Y, I and Q signals to supply digital red (R), green (G) and blue (B) signals to digital-to-analog converters 99, 100 and 101, respectively. Analog red (R), green (G) and blue (B) signals are supplied from the digital-to-analog converters 99, 100 and 101 to R, G and B kinescope driver amplifiers 102, 103 and 104, respectively. The R, G and B kinescope driver amplifiers 102, 103 and 104 supply red (R), green (G) and blue (B) drive signals to the kinescope 84.

The filter 94 has thusfar been termed an "equalization filter" and considered to be a filter that would provide a flat

frequency response through the band, which is the way this filter has been characterized by other workers in the ghost-cancellation art. In practice it is preferable to adjust the filter weights in the filter 94, not for flat frequency response through the band, but with a frequency response known to provide some transient over- and under-shooting, or video peaking. This reduces the need for providing transient overshooting or video peaking in the digital luma processing circuitry 96.

FIG. 6 shows a representative way of constructing the GCR signal capture processor 90. Random access memories 111, 112, 113 and 114 are arranged to serve as line stores for the GCR reference signals supplied during fields 00, 01, 10 and 11 of each cycle of four successive fields of digitized composite video signal. These GCR reference signals are supplied to the respective input ports of the RAMs 111, 112, 113 and 114 from the analog-to-digital converter 79. The four successive fields in each cycle are counted modulo-4 by a two-stage binary counter 115 that counts the ONEs generated by a decoder 116 that detects indications of the last scan line in a field furnished by the scan line count from the counter 87. As a preparatory measure in the procedure of updating the filter weighting coefficients in the ghost-cancellation filter 93 and in the equalization filter 94, the proper phasing of the modulo-4 field count can usually be determined by correlating the most recently received GCR signal, as de-ghosted, with each of the four standard GCR signals stored in the receiver, looking for best match. Decoders 121, 122, 123 and 124 decode the 100, 101, 110 and 111 signals as generated by the 19th line decoder 88 supplying most significant bit and field count from the field counter 115 supplying the two less significant bits, thereby to furnish write enable signals sequentially to the RAMs 111, 112, 113 and 114 during the 19th scan lines of successive fields.

The RAMs 111, 112, 113 and 114 are addressed in parallel by an address counter 125 that counts the number of samples per scan line. The address counter 125 receives the oscillations from the phase-locked oscillator 86 at its count input connection, and is reset by an edge of the horizontal sync pulse. This addressing scan during the 19th scan line allocates each successive digital composite video signal sample to a successive addressable location in the one of the RAMs 111, 112, 113 and 114 receiving a write enable signal. During the 20th scan line the decoder 89 provides a read enable signal to all of the RAMs 111, 112, 113 and 114. The addressing scan the counter 125 provides the RAMs 111, 112, 113 and 114 during the 20th scan line reads out the four most recently received and stored GCR signals parallely to a serial processor 126 that combines them to generate sequential samples of a separated Bessel pulse chirp signal and sequential samples of a separated PN sequence.

During the 20th scan line, the decoder 89 also provides a write enable signal to RAMs 127 and 128 that respectively serve as line stores for the separated chirp signal and separated PN sequence. The decoder 89 at the same time conditions address multiplexers 129 and 130 to select addresses from the address counter 125 as write addressing for the RAMs 127 and 128 respectively. The counter 125 provides the RAM 127 the addressing scan needed to write thereinto the sequential samples of the separated chirp signal from the serial processor 126. The counter 125 also provides the RAM 128 the addressing scan needed to write thereinto the sequential samples of the separated PN sequence from the serial processor 126. At times other than the 20th scan line, the address multiplexer 129 selects to the RAM 127 read addressing supplied to its RA terminal from the ghost-cancellation filter weight computer 91 during data fetching

operations, in which operations the computer **91** also supplies the RAM **127** a read enable signal. The RAM **127** supplies, at times other than the 20th scan line, the address multiplexer **130** selects to the RAM **128** read addressing supplied to its RA terminal from the equalization filter weight computer **92** during data fetching operations, in which operations the computer **92** also supplies the RAM **128** a read enable signal. The RAMs **127** and **128** have respective O terminal for supplying read output signals the ghost-cancellation filter weight computer **91** and to the equalization filter weight computer **92**, respectively.

FIGS. **7A**, **7B**, **7C** and **7D** are waveforms of the ghost cancellation reference signals in selected vertical blanking intervals of four successive fields of video, as embody the invention in one of its aspects, alternative to the aspect of the invention which FIGS. **1A**, **1B**, **1C** and **1D** concern. The GCR signals in FIGS. **7A** and **7D** are the same as those of FIGS. **1A** and **1D**. The GCR signals in FIGS. **7B** and **7C** differ from those of FIGS. **1B** and **1C** in that the swings of the PN sequences are reversed in direction. In FIGS. **7B** and **7C** the swings of the PN sequences **24'** and **34'** are in the same direction as the swings of the PN sequences **14** and **44** in FIGS. **7A** and **7D**.

FIG. **8** shows the separated Bessel pulse chirp waveform that results when the GCR signals from two successive fields that are in two successive frames are differentially combined, assuming that the GCR signals are of the sort shown in FIGS. **7A**, **7B**, **7C** and **7D**. A separated Bessel pulse chirp waveform per FIG. **8** results when the GCR signals of FIGS. **7B** and **7C** are differentially combined. A separated Bessel pulse chirp waveform per FIG. **8** also results when the GCR signals of FIGS. **7D** and **7A** are differentially combined. A separated Bessel pulse chirp waveform per FIG. **8** also results when the sum of the GCR signals of FIGS. **7A** and **7B** is differentially combined with the sum of the GCR signals of FIGS. **7C** and **7D**.

FIG. **9** shows the waveform that results when the GCR signals from four (or any multiple of four) successive fields are additively combined or are averaged, assuming that the GCR signals are of the sort shown in FIGS. **7A**, **7B**, **7C** and **7D**. The Bessel pulse chirp waveform and the chroma burst are suppressed in this signal. The DC level and "gray" pedestal are maintained in this signal as well as the PN sequence. The PN sequence can then be separated by high-pass digital filtering. The DC level and "gray" pedestal can be separated by low-pass digital filtering. The DC level and "gray" pedestal are useful in circuitry for controlling the gain and DC-offset of the analog composite signal applied to the analog-to-digital converter **79**. Circuits are known in the prior art in which the digital output signal of an analog-to-digital converter is selected as input signal to a first digital comparator during a portion of the digitized composite video signal known to be supposedly at 0 IRE level, there to be compared against digitized ideal 0 IRE level to develop a first digital error signal that is converted to analog error by a digital-to-analog converter and fed back to degenerate error in the 0 IRE level against which the input signal to the analog-to-digital converter is DC-restored. In certain of these circuits the digital output signal of the same analog-to-digital converter is selected as input signal to a second digital comparator during a portion of the digitized composite video signal known to be supposedly at a prescribed pedestal level, there to be compared against the prescribed pedestal level in digital form to develop a second digital error signal that is converted to analog error by a digital-to-analog converter and fed back as an automatic gain control (AGC) signal to a gain-controlled amplifier preceding the analog-to-digital converter and keeping the input signal to the analog-to-digital converter quite exactly within the bounds of the conversion range.

FIG. **10** shows how the FIG. **6** serial processor may be constructed for processing the ghost cancellation reference signals of FIGS. **1A**, **1B**, **1C** AND **1D** to generate the FIG. **2** and FIG. **3** signals. A serial adder **131** sums the RAM **111** output signal per FIG. **1A** with the RAM **112** output signal per FIG. **1B**. A serial adder **132** sums the RAM **113** output signal per FIG. **1C** with the RAM **114** output signal per FIG. **1D**. A serial subtractor **133** subtracts the sum output of the adder **132** from the sum output of the adder **131** to generate a separated Bessel pulse chirp signal. With a bit point shift of two places towards less significance, for carrying out wired division by four, this separated Bessel pulse chirp signal is the FIG. **2** signal. A serial adder **134** sums the RAM **111** output signal per FIG. **1A** with the RAM **114** output signal per FIG. **1D**. A serial adder **135** sums the RAM **112** output signal per FIG. **1B** with the RAM **113** output signal per FIG. **1C**. A serial subtractor **136** subtracts the sum output of the adder **135** from the sum output of the adder **134** to generate a separated PN sequence signal. With a bit point shift of two places towards less significance, for carrying out wired division by four, this separated PN sequence signal is the FIG. **3** signal.

FIG. **11** shows how the FIG. **6** serial processor may be constructed for processing the ghost cancellation reference signals of FIGS. **7A**, **7B**, **7C** and **7D** to generate the FIG. **8** and FIG. **9** signals. Serial adders **131** and **132** and serial subtractor **133** cooperate to generate a separated Bessel pulse chirp signal, as described in connection with FIG. **10**. With a bit point shift of two places towards less significance, for carrying out wired division by four, this separated Bessel pulse chirp signal is the FIG. **8** signal. A serial adder **137** sums the sum outputs of the adders **131** and **132** to generate a separated PN sequence signal. With a bit point shift of two places towards less significance, for carrying out wired division by four, this separated PN sequence signal is the FIG. **9** signal.

The foregoing description assumes that only one VBI scan line per field is made available by television broadcasters. The availability of two successive VBI scan lines in each field allows their being added to cancel color burst within the period of a single scan line, lessening the possibility that fast fading conditions will lead to imperfect cancellation of color burst or to misalignment of GCR signals when they are combined. Also, the time required to acquire the data necessary for the calculations of ghost cancellation and equalization parameters is halved. By way of example, the GCR signals of FIGS. **1A** and **1B** could be in the 19th and the 20th scan lines of the first field of each frame; and the GCR signals of FIGS. **1C** and **1D** could be in the 19th and 20th scan lines of the second field of each frame. Alternatively, by way of further example, the GCR signals of FIGS. **7A** and **7B** could be in the 19th and the 20th scan lines of the first field of each frame; and the GCR signals of FIGS. **7C** and **7D** could be in the 19th and the 20th scan lines of the second field of each frame.

The FIG. **5** television receiver can be modified to include a **1H** delay line connected at its input to receive video signal from the video detector **74**. This facilitates addition of the 19th and the 20th scan lines of each field being done in the analog regime by adding the signals at the input and output of a **1H** delay line to supply input signal to the ADC **79**. Where the GCR signals of FIGS. **7A–7D** are used, the color burst is cancelled and both the chirp and PN sequence signals are strengthened prior to digitization by the ADC **79**.

This reduces errors arising from round-off during digitization and from the sampling during digitization not being timed exactly the same from line to line. The decoders **88** and **89** are modified to detect scan lines **20** and **21**, thus taking into account the delay introduced by the 1H delay line. Alternatively, modifications of the FIG. **5** television receiver can be such that the 19th and the 20th scan lines of each field are combined in the digital regime; this is done through suitable modification of the GCR signal capture processor, changing the read and write addressing of the GCR line-store RAMs therein. Instead of including GCR signal components in the 19th and the 20th scan lines of each field, GCR signal can be included in the 18th and the 19th scan lines of each field. In still other alternatives, GCR signal components are included in the 18th and the 20th scan lines of each field, so that horizontal sync as well as color burst portions of the signal can be suppressed by differentially combining the corresponding pixels of the two scan lines, while anti-phase chirp or PN sequence components combine constructively.

The voluntary standard for GCR signals in the United States is now the U.S. Philips Corp. proposal using Bessel chirps. The voluntary standard is described in a paper by L. D. Claudy and S. Herman entitled "GHOST CANCELING: A New Standard for NTSC Broadcast Television" and presented Sep. 17, 1992 at the IEEE Broadcast Technology Symposium in Washington D.C. The foregoing teachings in regard to television receiver design have application to GCR signals per the voluntary standard, particularly with regard to the GCR signal capture processor and to the extraction of chirp pedestal information. The GCR signals of the voluntary standard are inserted into the 19th line of each field and repeat in an eight-field cycle, rather than the four-field cycle explicitly described above. The GCR signal capture processor **90** as shown in FIG. **6** is readily modified to augment the modulo-**4** field counter **115** with an additional counter stage or two, thereby to provide a modulo-**8** field counter or a modulo-**16** field counter; to add additional GCR signal line store RAMs for storing one or two eight-field cycles of the GCR signals of the voluntary standard; and to add field-count decoders for selectively writing the additional GCR signal line store RAMs. Initial rough calculations of ghost cancellation parameters may be made by combining only a pair of the GCR signals of the voluntary standard, so as to separate chirp signal, with a greater number of pairs of GCR signals being combined later on to support refined calculations of ghost cancellation parameters. The computation of equalizing parameters for application to the equalization filter **94** is done proceeding from the separated Bessel chirp, rather than from a separated PN sequence, of course.

Further refinements in the inventor's GCR signal capture processor are described in their U.S. patent application Ser. No. 07/984,488 filed Dec. 2, 1992 and entitled GHOST CANCELATION REFERENCE SIGNAL ACQUISITION CIRCUITRY, AS FOR TV RECEIVER OR VIDEO RECORDER, the drawing and specification of which are appended hereto for incorporation herein.

One skilled in the art of electronic circuits and systems design and acquainted with the foregoing disclosure will be enabled to design a number of variants of the signals and circuits specifically disclosed; and this should be borne in mind when considering the respective scopes of the claims which follow.

What is claimed is:

1. An apparatus for transmitting a television signal divided into a plurality of successive fields for reception by a television receiver including adaptive ghost suppression filtering, each said field consisting of a prescribed number of lines of information, said lines being of uniform respective duration, said apparatus characterized by including:

a reference signal generator for transmitting during a prescribed single line of each of said fields a first ghost-cancellation reference signal and a second ghost-cancellation reference signal different than said first ghost-cancellation reference signal, each of said first and said second ghost-cancellation reference signals being transmitted with a modulation swing less than the maximum modulation swing available but more than half said maximum modulation swing, the relative phases of said first and said second ghost-cancellation reference signals varying from field to field in prescribed pattern to facilitate their separation at said television receiver, said first ghost-cancellation reference signal having a prescribed first duration longer than half a line duration to provide said television receiver sufficient energy for detecting ghosts with long differential delay and low energy to furnish a basis for calculation of adjustments of said adaptive ghost suppression filtering to suppress said ghosts with long differential delay and low energy, and said second ghost-cancellation reference signal having a prescribed second duration shorter than half a line duration to facilitate more rapid calculation of adjustments of said adaptive ghost suppression filtering in said television receiver to suppress ghosts with substantial energy and less differential delay.

2. The apparatus of claim **1**, wherein at least one of said first and said second ghost-cancellation reference signals is a pseudo-noise (PN) sequence.

3. The apparatus of claim **1**, wherein said second ghost-cancellation reference signal is a pseudo-noise (PN) sequence.

4. The apparatus of claim **1**, wherein said second ghost-cancellation reference signal follows said first ghost-cancellation reference signal in said prescribed single line of each of said fields.

5. The apparatus of claim **4**, wherein said first reference signal is a Bessel chirp signal.

6. The apparatus of claim **4**, wherein said second ghost-cancellation reference signal is a pseudo-noise (PN) sequence.

7. A receiver, including adaptive ghost suppression filtering, for receiving a signal transmission over a reception channel, said signal transmission divided into a plurality of successive fields having a prescribed number of lines of information and being of uniform respective duration, said receiver including:

an input for receiving in a prescribed single line of each of said fields a first ghost-cancellation reference signal and a second ghost-cancellation reference signal different than said first ghost-cancellation reference signal, each of said first and said second ghost-cancellation reference signals having a modulation swing less than the maximum modulation swing available but more than half said maximum modulation swing, the relative phases of said first and said second ghost-cancellation reference signals varying from field to field in prescribed pattern to facilitate their separation by said receiver, said first ghost-cancellation reference signal having a prescribed first duration longer than half a line duration to provide said receiver sufficient energy for detecting ghosts with long differential delay and low energy to furnish a basis for calculation of adjustments of said adaptive ghost sup-

pression filtering to suppress said ghosts with long differential delay and low energy, and said second ghost-cancellation reference signal having a prescribed second duration shorter than half a line duration to facilitate more rapid calculation of adjustments of said adaptive ghost suppression filtering in said receiver to suppress ghosts with substantial energy and less differential delay.

8. The receiver of claim 7, wherein at least one of said first and said second ghost-cancellation reference signals is a pseudo-noise (PN) sequence.

9. The receiver of claim 7, wherein said second ghost-cancellation reference signal is a pseudo-noise (PN) sequence.

10. The receiver of claim 7, wherein said second ghost-cancellation reference signal follows said first ghost-cancellation reference signal in said prescribed single line of each of said fields.

11. The receiver of claim 10, wherein said first reference signal is a Bessel chirp signal.

12. The receiver of claim 10, wherein said second ghost-cancellation reference signal is a pseudo-noise (PN) sequence.

13. A television apparatus comprising:

a receiver adapted for receiving a television signal in a predetermined signal format over a reception channel, said signal format comprising a frame having a first field and a second field,

(1) wherein said first field comprises:

(1a) at least one segment which has a set of values which are known in advance by the receiver of said television apparatus, wherein said segment includes:

(i) a first ghost cancellation reference signal, and

(ii) a second ghost cancellation reference signal including pseudo noise sequence, wherein said first reference signal is longer than said second reference signal; and

(1b) an image signal containing image content of said television signal; and

(2) wherein said second field comprises:

(2a) at least one segment which has a set of values which are known in advance by the receiver of said television apparatus, wherein said segment includes:

(i) a first ghost cancellation reference signal, and

(ii) a second ghost cancellation reference signal including pseudo noise sequence, said pseudo noise sequence of said second field being of opposite polarity to said pseudo noise sequence of said first field, wherein said first reference signal is longer than said second reference signal; and

(2b) an image signal containing image content of said television signal; and

a processor for processing at least one of said first ghost cancellation reference signal and said second ghost cancellation reference signal for determining information to be used for reducing multi-path distortion.

14. A television signal format comprising:

a frame including a first field and a second field,

(1) wherein said first field comprises:

(1a) at least one segment which has a set of values which are known in advance by a receiver of said television signal format, wherein said segment includes:

(i) a first ghost cancellation reference signal, and

(ii) a second ghost cancellation reference signal including pseudo noise sequence, wherein said first reference signal is longer than said second reference signal; and

(1b) an image signal containing image content of the television signal; and

(2) wherein said second field comprises:

(2a) at least one segment which has a set of values which are known in advance by a receiver of said television signal format, wherein said segment includes:

(i) a first ghost cancellation reference signal, and

(ii) a second ghost cancellation reference signal including pseudo noise sequence, said pseudo noise sequence of said second field being of opposite polarity to said pseudo noise sequence of said first field, wherein said first reference signal is longer than said second reference signal; and

(2b) an image signal containing image content of the television signal.

15. A circuit for processing a digitized television signal, said digitized television signal comprising a succession of frames, where each of said frames comprises a first field and a second field, and where each of said fields comprises a specified number of lines, one of said lines being designated to carry a first ghost-cancellation reference signal and a second ghost-cancellation reference signal, said circuit comprising:

signal recovery circuitry connected to receive said digitized television signal and to retrieve therefrom at least one of said first ghost-cancellation reference signal and said second ghost-cancellation reference signal as a function of said first ghost-cancellation reference signal having the same polarity from one field to a next field, and as a function of said second ghost-cancellation reference signal having opposite polarity from one field to the next field, wherein said first ghost-cancellation reference signal is longer than said second ghost-cancellation reference signal, and wherein said second ghost-cancellation reference signal comprises a pseudo-random noise sequence;

adaptive filter coefficient calculation circuitry responsive to at least one of said first and said second ghost-cancellation reference signals; and

digital filter circuitry connected to receive said digitized television signal with accompanying multipath distortion, wherein said digital filter circuitry is responsive to adaptive filter coefficients calculated by said adaptive filter coefficient calculation circuitry, and wherein said digital filter circuitry supplies as an output signal, said digitized television signal with reduced multipath distortion.

16. The circuit of claim 15, wherein said first ghost-cancellation reference signal and said second ghost-cancellation reference signal have a substantially flat frequency response.

17. A circuit for processing a digitized television signal, said digitized television signal comprising a succession of frames, where each of said frames comprises a first field and a second field, and where each of said fields comprises a specified number of lines, at least one of said lines being designated to carry a first ghost-cancellation reference signal and a second ghost-cancellation reference signal, said circuit comprising:

signal recovery circuitry connected to receive said digitized television signal and to retrieve therefrom at least one of said first ghost-cancellation reference signal and said second ghost-cancellation reference signal as a

function of said first ghost-cancellation reference signal having the same polarity from one field to a next field, and as a function of said second ghost-cancellation reference signal having opposite polarity from one field to the next field, wherein said first ghost-cancellation reference signal is longer than said second ghost-cancellation reference signal, and wherein said second ghost-cancellation reference signal comprises a pseudo-random noise sequence;

adaptive filter coefficient calculation circuitry responsive to at least one of said first and said second ghost-cancellation reference signals; and

digital filter circuitry connected to receive said digitized television signal with accompanying multipath distortion, wherein said digital filter circuitry is responsive to adaptive filter coefficients calculated by said adaptive filter coefficient calculation circuitry, and wherein said digital filter circuitry supplies as an output signal, said digitized television signal with reduced multipath distortion.

18. An apparatus for detecting and processing a composite video signal comprising a succession of frames, where each of said frames comprises a first field and a second field, and where each of said fields comprises a specific number of data sequences with at least one of said data sequences in each field containing a first ghost-cancellation reference signal and a second ghost-cancellation reference signal, said apparatus comprising:

means for sampling said composite video signal:

means for recovering from said sampled composite video signal at least one of said first ghost-cancellation reference signal and said second ghost-cancellation reference signal, wherein said first ghost-cancellation reference signal is longer than said second ghost-cancellation reference signal, and wherein said second ghost-cancellation reference signal is a pseudo-random noise sequence having a polarity that is inverted every other field:

means for calculating one or more adaptive filter coefficients as a function of at least one of said first and said second ghost-cancellation reference signals; and

filter means for reducing multipath distortion from said sampled composite video signal as a function of said one or more adaptive filter coefficients.

19. The apparatus of claim **18**, further comprising:

means for deriving an error signal as a function of a known reference sequence and at least one of said first ghost-cancellation reference signal and said second ghost-cancellation signal.

20. The apparatus of claim **19**, wherein said means for calculating one or more adaptive filter coefficients as a function of at least one of said first and said second ghost-cancellation reference signals comprises:

means for calculating one or more adaptive filter coefficients as a function of said error signal.

21. A method for detecting and processing a composite video signal comprising a succession of frames, where each of said frames comprises a first field and a second field, and where each of said fields comprises a specific number of data sequences with one of said data sequences in each field containing a first ghost-cancellation reference signal and a second ghost-cancellation reference signal, said method comprising the steps of:

sampling said composite video signal;

recovering from said sampled composite video signal at least one of said first ghost-cancellation reference signal and said second ghost-cancellation reference signal, wherein said first ghost-cancellation reference signal is longer than said second ghost-cancellation reference signal, wherein said second ghost-cancellation reference signal is a pseudo-random noise sequence, and wherein said polarity of said second ghost-cancellation reference signal is inverted every other frame;

calculating one or more adaptive filter coefficients as a function of at least one of said first and said second ghost-cancellation reference signals; and

reducing multipath distortion from said sampled composite video signal as a function of said one or more adaptive filter coefficients.

* * * * *

EXHIBIT 3

US006937292B1

(12) **United States Patent**
Patel et al.

(10) **Patent No.: US 6,937,292 B1**
(45) **Date of Patent: Aug. 30, 2005**

(54) **GHOST CANCELLATION REFERENCE SIGNAL WITH BESSEL CHIRPS AND PN SEQUENCES, AND TV RECEIVER USING SUCH SIGNAL**

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(73) Assignee: **Samsung Electronics Co., Ltd.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **08/158,299**

(22) Filed: **Nov. 29, 1993**

Related U.S. Application Data

(63) Continuation-in-part of application No. 07/872,077, filed on Apr. 22, 1992, now abandoned, and a continuation-in-part of application No. 07/984,488, filed on Dec. 2, 1992, now abandoned.

(51) **Int. Cl.**[7] **H04N 5/21**; H04N 5/213; H04N 5/217

(52) **U.S. Cl.** **348/614**

(58) **Field of Search** 348/608, 614, 348/611; H04N 5/213, 5/217, 5/21

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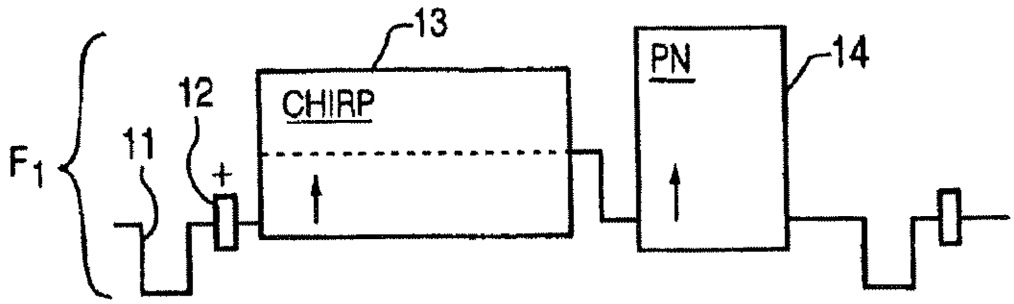
Primary Examiner—Michael H. Lee
(74) *Attorney, Agent, or Firm*—Howrey Simon Arnold & White, LLP

(57) **ABSTRACT**

Composite ghost cancellation reference (GCR) signals that make available both a chirp and a PN sequence during the same VBLI in each successive field facilitates the more rapid and efficient calculations of ghost cancellation and of equalization, on a continuing basis. A television receiver for use with such composite GCR signals includes means for separating the chirp and PN sequence portions of the GCR signals from the remainder of the composite video signal, a ghost cancellation filter and an equalization filter connected in cascade to respond to the composite video signal and provided each with adjustable filtering weights, means responding to the separated chirp portions of the GCR signals to calculate a discrete Fourier transform (DFT) therefrom, means responding to that DFT to determine the adjustable filtering weights of the ghost cancellation filter, and means responding to the separated PN sequences to determine the adjustable filtering weights of the equalization filter.

26 Claims, 6 Drawing Sheets



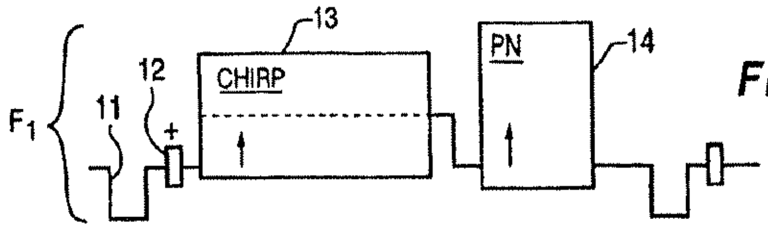


Fig. 1A

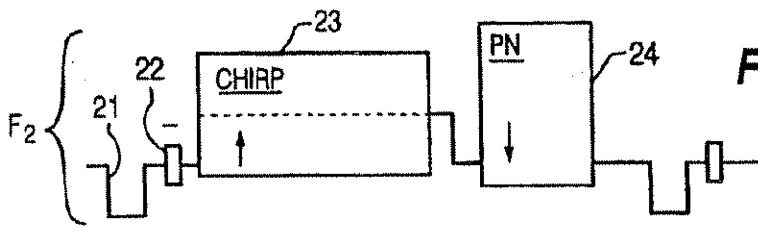


Fig. 1B

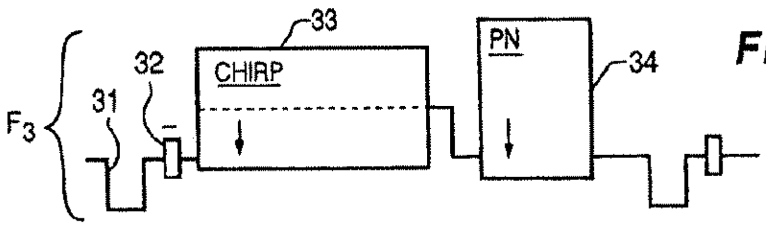


Fig. 1C

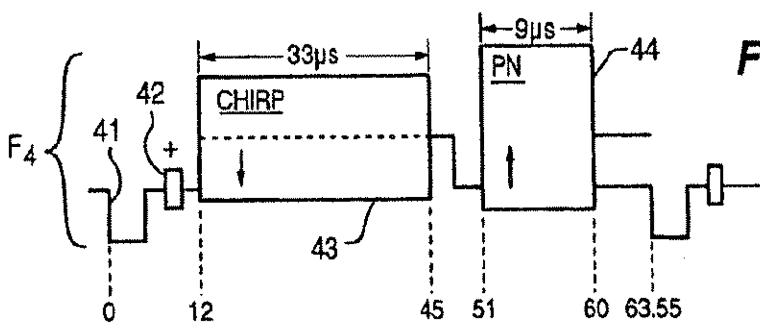


Fig. 1D

Fig. 2

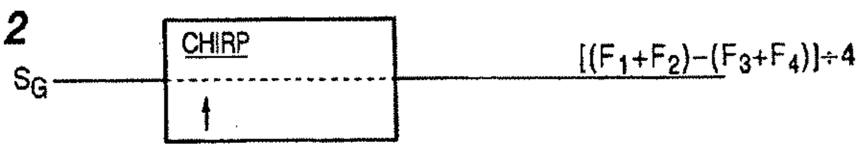
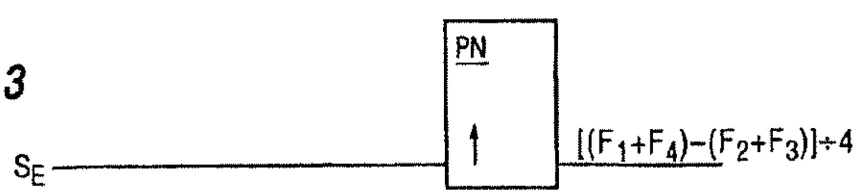


Fig. 3



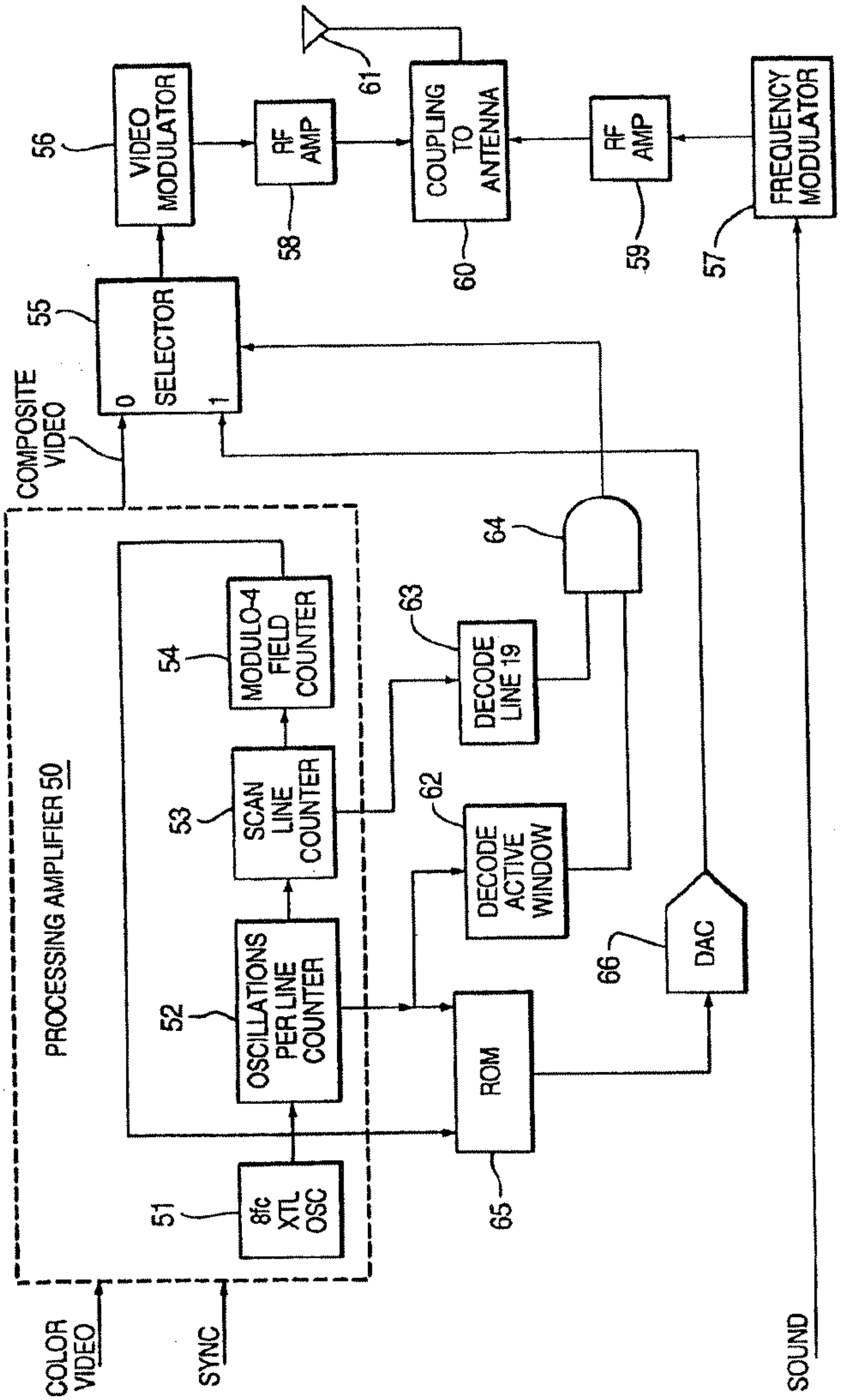
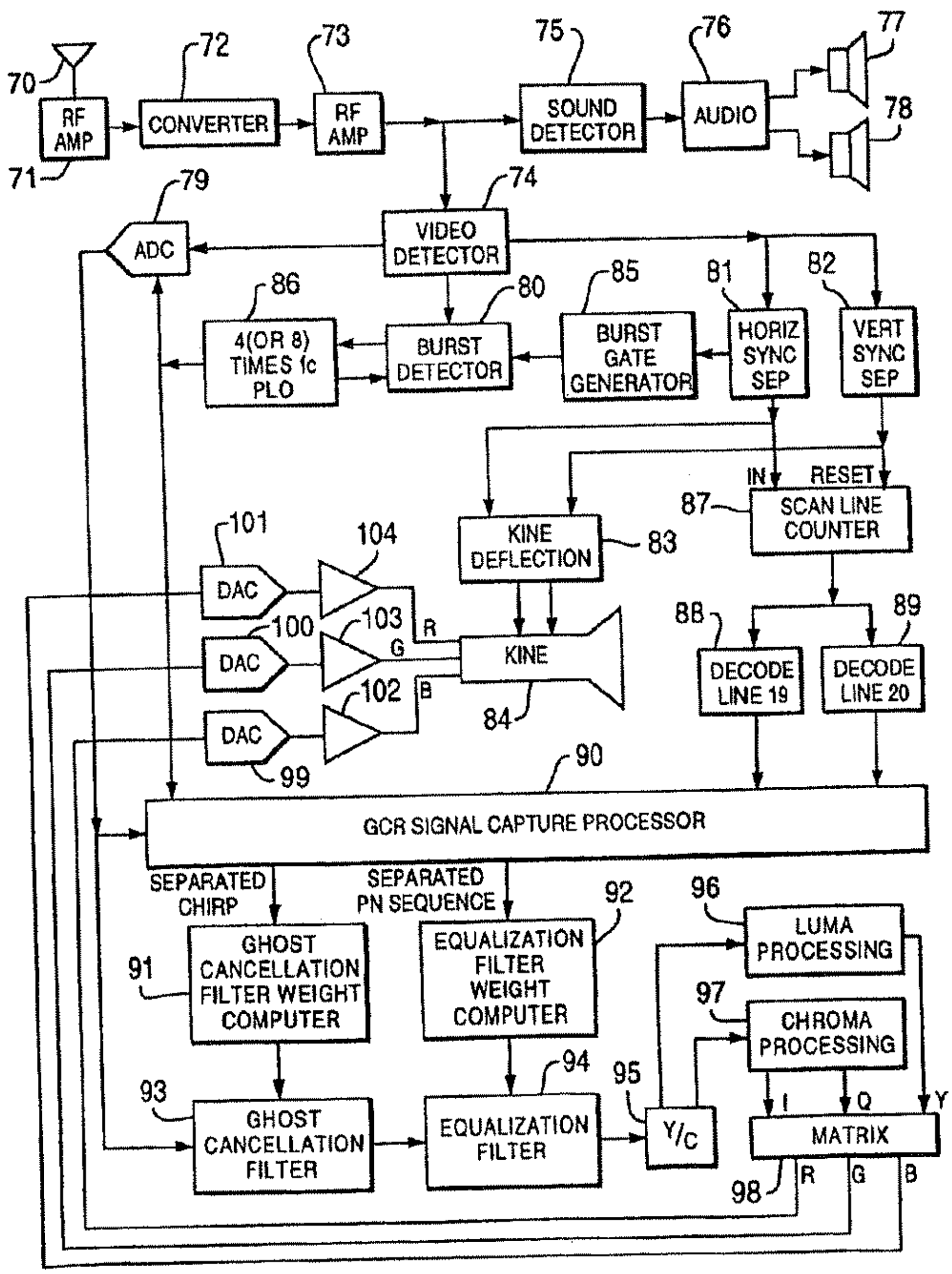

COLOR VIDEO
SYNC
SOUND
PROCESSING AMPLIFIER 50
8fc XTL OSC
51
OSCILLATIONS PER LINE COUNTER
52
SCAN LINE COUNTER
53
MODULO-4 FIELD COUNTER
54
COMPOSITE VIDEO
SELECTOR
0
1
55
VIDEO MODULATOR
56
RF AMP
58
COUPLING TO ANTENNA
60
61
RF AMP
59
FREQUENCY MODULATOR
57
64
DECODE LINE 19
63
DECODE ACTIVE WINDOW
62
ROM
65
DAC
66

Fig. 4


RF AMP
CONVERTER
RF AMP
SOUND DETECTOR
AUDIO
VIDEO DETECTOR
ADC
4(OR 8) TIMES fc PLO
BURST DETECTOR
BURST GATE GENERATOR
HORIZ SYNC SEP
VERT SYNC SEP
IN
RESET
SCAN LINE COUNTER
KINE DEFLECTION
DAC
DAC
DAC
R
G
B
KINE
DECODE LINE 19
DECODE LINE 20
GCR SIGNAL CAPTURE PROCESSOR
SEPARATED CHIRP
SEPARATED PN SEQUENCE
GHOST CANCELLATION FILTER WEIGHT COMPUTER
EQUALIZATION FILTER WEIGHT COMPUTER
LUMA PROCESSING
CHROMA PROCESSING
GHOST CANCELLATION FILTER
EQUALIZATION FILTER
Y/C
I
Q
Y
MATRIX
R
G
B
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
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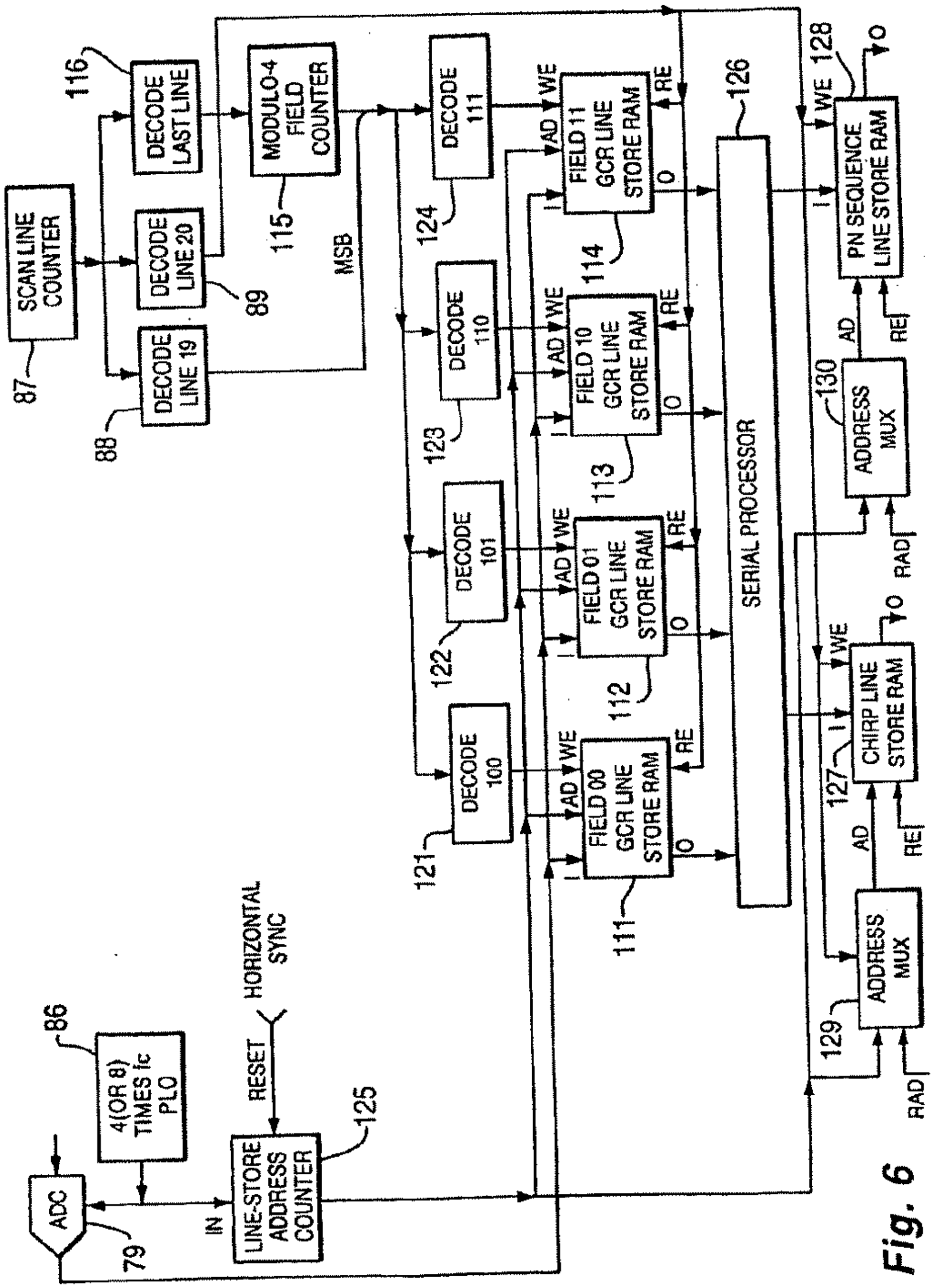
102
103
104

Fig. 5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87
DECODE LINE 19
88
DECODE LINE 20
89
DECODE LAST LINE
116
MODULO-4 FIELD COUNTER
115
MSB
DECODE 111
124
DECODE 110
123
DECODE 101
122
DECODE 100
121
FIELD 11 GCR LINE STORE RAM
114
FIELD 10 GCR LINE STORE RAM
113
FIELD 01 GCR LINE STORE RAM
112
FIELD 00 GCR LINE STORE RAM
111
WE
AD
RE
I
O
SERIAL PROCESSOR
126
PN SEQUENCE LINE STORE RAM
128
ADDRESS MUX
130
CHIRP LINE STORE RAM
127
ADDRESS MUX
129
RAD
4(OR 8) TIMES fc PLO
86
ADC
79
IN
LINE-STORE ADDRESS COUNTER
125
RESET
HORIZONTAL SYNC

Fig. 6

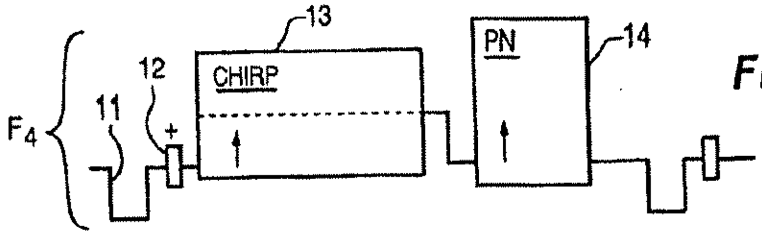


Fig. 7A

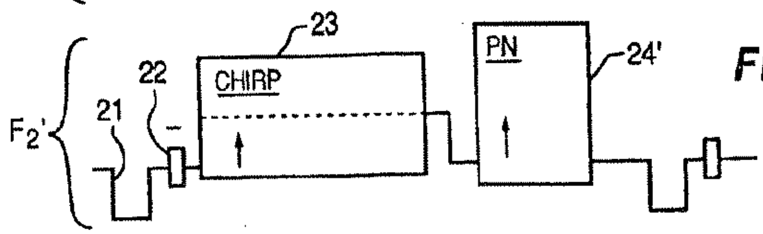


Fig. 7B

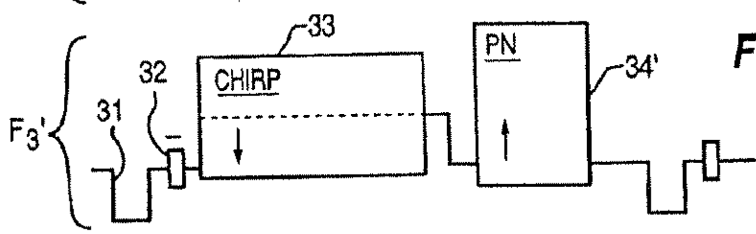


Fig. 7C

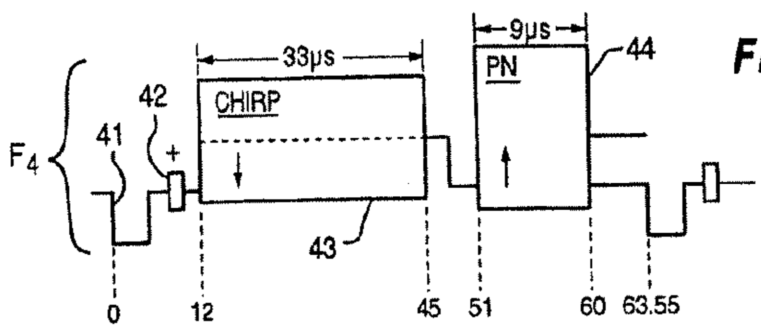


Fig. 7D

Fig. 8

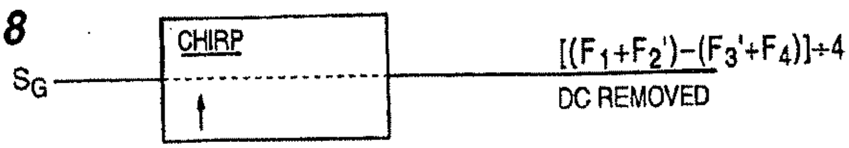
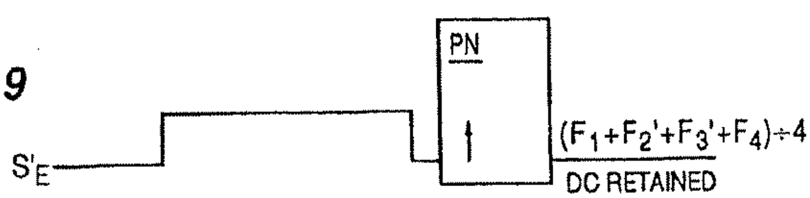


Fig. 9



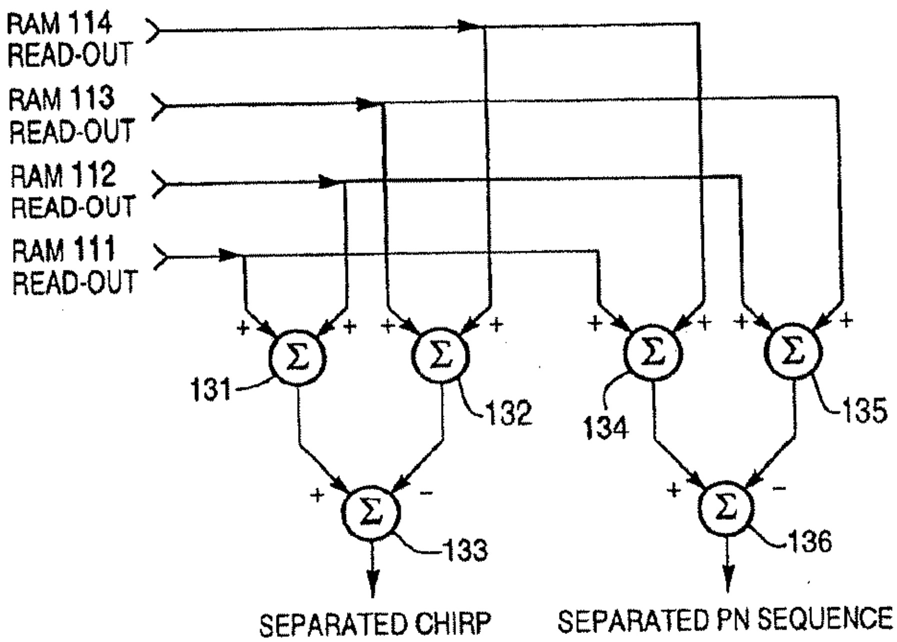

RAM 114 READ-OUT
RAM 113 READ-OUT
RAM 112 READ-OUT
RAM 111 READ-OUT
131
132
133
134
135
136
SEPARATED CHIRP
SEPARATED PN SEQUENCE

Fig. 10

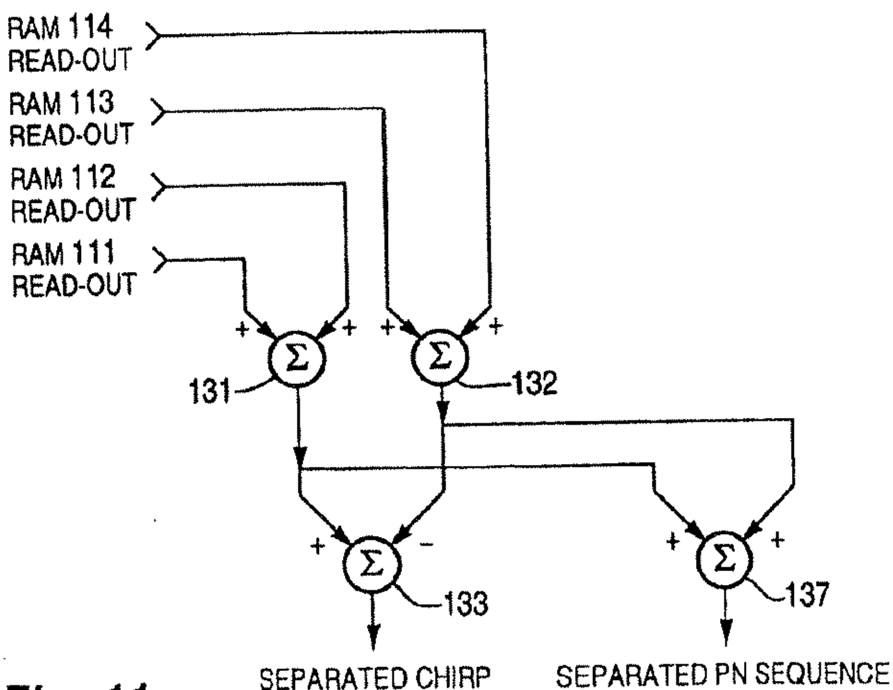

RAM 114 READ-OUT
RAM 113 READ-OUT
RAM 112 READ-OUT
RAM 111 READ-OUT
131
132
133
137
SEPARATED CHIRP
SEPARATED PN SEQUENCE

Fig. 11

GHOST CANCELLATION REFERENCE SIGNAL WITH BESSEL CHIRPS AND PN SEQUENCES, AND TV RECEIVER USING SUCH SIGNAL

This is a continuation-in-part of U.S. patent application Ser. No. 07/872,077 filed Apr. 22, 1992 now abandoned and is a continuation-in-part of U.S. patent application Ser. No. 07/984,428 Dec. 2, 1992, now abandoned.

BACKGROUND OF THE INVENTION

Subcommittee T-3 of the Advanced Television Systems Committee has been meeting to determine a GCR signal for use in the United States. The GCR signal will be a compromise based from two GCR signals, one using Bessel pulse chirp signals as proposed by U.S. Philips Corp. and one using pseudo noise (PN) sequences as proposed by the David Sarnoff Research Center (DSRC) of Stanford Research Institute. The GCR signals are inserted into selected vertical blanking intervals (VBIs). The GCR signals are used in a television receiver for calculating the adjustable weighting coefficients of a ghost-cancellation filter through which the composite video signals from the video detector are passed to supply a response in which ghosts are suppressed. The weighting coefficients of this ghost-cancellation filter are adjusted so it has a filter characteristic complementary to that of the transmission medium giving rise to the ghosts. The GCR signals can be further used for calculating the adjustable weighting coefficients of an equalization filter connected in cascade with the ghost-cancellation filter, for providing an essentially flat frequency spectrum response over the complete transmission path through the transmitter vestigial-sideband amplitude-modulator, the transmission medium, the television receiver front-end and the cascaded ghost-cancellation and equalization filters.

In the conventional method for cancelling ghosts in a television receiver, the discrete Fourier transform (DFT) of the ghosted GCR signal is divided by the DFT of the non-ghosted GCR signal (which latter OFT is known at the receiver from prior agreement with the transmitter) to obtain as a quotient the DFT transform of the transmission medium giving rise to ghosting; and the inverse DFT of this quotient is then used to define the filter weighing coefficients of a compensating ghost-cancellation filter through which the ghosted composite video signal is passed to obtain a de-ghosted composite video signal. To implement the DFT procedure efficiently, in terms of hardware or of calculations required in software, an integral power of two equal-bandwidth frequency bins are used in the DFT. The distribution of energy in the Philips chirp signal has a frequency spectrum extending continuously across the composite video signal band, in contrast to the DSRC PN sequence in which the distribution of energy does not extend continuously across the composite video signal band, but exhibits nulls in its frequency distribution. Accordingly, when the number of equal-bandwidth frequency bins in the DFT is reduced in order to speed calculation time, more accurate ghost cancellation is obtained with the chirp than with the PN sequence as GCR signal, the inventors observe.

During official testing by the Subcommittee, the DSRC GCR signal has exhibited somewhat better performance in regard to equalization of the passband after ghosting, which some experts including the Philips engineers, attribute to better filter hardware.

Theoretically, equalization calculated over an entire active portion of the VBI, proceeding from the PN sequence, has an accuracy substantially the same as the accuracy available calculating equalization from the chirp signal. The entire length of the Philips chirp signal is needed to have the requisite information to implement equalization over the full composite video signal band, The PN sequence contains pulse transitions each of which transitions has substantially the entire frequency spectrum contained therein. The PN sequence contains many pulse transitions, each of which transitions has component frequencies extending over substantially the entire frequency spectrum. This property of the PN sequence, the inventors observe, permits the calculation of equalization taking samples at a prescribed sampling density only over a limited extent of the GCR signal. Taking samples over only a portion of the GCR signal causes some loss in the accuracy with which equalization can be calculated, particularly under poor signal-to-noise conditions. However, since the number of samples involved in the calculation of weighting coefficients for the equalization filter is reduced, there can be an appreciable increase in the speed with which equalization can be calculated, presuming the calculation is done using an iterative method such as least-mean-squares error reduction. Also, there is reduced complexity, in terms of hardware or of calculations required in software, with regard to calculating the equalization filter weighting coefficients.

The composite GCR signals comprised of chirps and PN sequence signals that have thus far been proposed do not make available both a chirp and a PN sequence during the same VBLI scan line.

SUMMARY OF THE INVENTION

The inventors observe that making both a chirp and a PN sequence available during the same VBLI scan line in each successive field, facilitates the more rapid and efficient calculations of ghost cancellation and of equalization, on a continuing basis, particularly when the transmission medium exhibits continual change—e.g., during the rapidly changing ghost conditions caused in over-the-air transmissions by overflying aircraft. A television receiver embodying the invention includes means for separating the chirp and PN sequence portions of the ghost cancellation reference (GCR) signal from the remainder of the composite video signal, a ghost cancellation filter and an equalization filter connected in cascade to respond to the composite video signal and provided each with adjustable filtering weights, means responding to the separated chirp portion of the GCR signal to calculate its discrete Fourier transform (DFT), means responding to that DFT to determine the adjustable filtering weights of the ghost cancellation filter, and means responding to the separated PN sequence to determine the adjustable filtering weights of the equalization filter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A, 1B, 1C and 1D are waveforms of the ghost cancellation reference signals in selected vertical blanking intervals of four successive fields of video, as embody the invention in one of its aspects.

FIG. 2 is the waveform of a separated chirp signal as formed by differentially combining the sum of the ghost cancellation reference signals of FIGS. 1A and 1B with the sum of the ghost cancellation reference signals of FIGS. 1C and 1D.

FIG. 3 is the waveform of a separated PN sequence as formed by differentially combining the sum of the ghost cancellation reference signals of FIGS. 1A and 1D with the sum of the ghost cancellation reference signals of FIGS. 1B and 1C.

FIG. 4 is a schematic diagram of a television modulator arranged for transmitting the signals of FIGS. 1A, 1B, 1C and 1D.

FIG. 5 is a schematic diagram of a television receiver arranged to receive television signals incorporating the ghost cancellation reference signals of FIGS. 1A, 1B, 1C and 1D, to a suppress ghosts accompanying those television signals and to equalize the transmission channel across the video bandwidth.

FIG. 6 is a schematic diagram of the GCR signal capture processor shown as a block in FIG. 5.

FIGS. 7A, 7B, 7C and 7D are waveforms of the ghost cancellation reference signals in selected vertical blanking intervals of four successive fields of video, as embody the invention in one of its aspects, alternative to the aspect of the invention illustrated by FIGS. 1A, 1B, 1C and 1D.

FIG. 8 is the waveform of a separated chirp signal as formed by combining the ghost cancellation reference signals of FIGS. 7B and 7C, of FIGS. 7D and 7A, or of FIGS. 7A, 7B, 7C and 7D.

FIG. 9 is the waveform of a separated PN sequence preceded by a "gray" pedestal, as formed by combining the ghost cancellation reference signals of FIGS. 7A, 7B, 7C and 7D.

FIG. 10 is a schematic diagram of the FIG. 6 serial processor for processing the ghost cancellation reference signals of FIGS. 1A, 1B, 1C and 1D to generate the FIG. 2 and FIG. 3 signals.

FIG. 11 is a schematic diagram of the FIG. 6 serial processor for processing the ghost cancellation reference signals of FIGS. 7A, 7B, 7C and 7D to generate the FIG. 8 and FIG. 9 signals.

DETAILED DESCRIPTION OF THE INVENTION

FIGS. 1A, 1B, 1C and 1D show the ghost cancellation reference signals in selected scan lines of the vertical blanking intervals of four successive fields of video. Insertion may be into any one of the 11^{th} through 20^{th} scan lines of each field, the present preference being to replace the vertical interval reference (VIR) signal currently used in the 19^{th} scan line of each field. To simplify the description that follows, insertion of GCR signal into the 19^{th} scan line of each field will be assumed by way of specific illustration.

The ghost cancellation reference signals of FIGS. 1A, 1B, 1C and 1D begin with horizontal synchronization pulses 11, 21, 31 and 41, respectively, which pulses are shown as being negative-going. The leading edges of the horizontal synchronization pulses are considered to be the beginning of VBLI scan lines that are each of 63.55 microsecond duration in NTSC standard television signals. The horizontal synchronization pulses 11, 21, 31 and 41 are respectively followed during ensuing back-porch intervals by chroma bursts 12, 22, 32 and 42. The plus and minus signs near the chroma bursts 12, 22, 32 and 42 indicate their relative polarities respective to each other, per the NTSC standard.

Bessel pulse chirps 13, 23, 33 and 43 each of 33 microsecond duration begin 12 microseconds into the VBLI scan lines of FIGS. 1A, 1B, 1C and 1D, respectively. The arrows associated with each of these chirps is indicative of its relative polarity with respect to the other chirps; chirp polarity is shown as alternating from frame to frame. These chirps swing plus/minus 40 IRE from 30 IRE "gray" pedestals which extend from 12 to 48 microseconds into these VBLI lines. The gray level of the pedestals, the plus/minus swing of the chirps, the duration of the pedestals and the duration of the chirps have been specified to correspond as closely as possible to the Philips system that has been officially tested; and design variations may be expected to occur should the compromise GCR signals described herein be adopted by the Subcommittee as their official recommendation for a standard.

Beginning at 51 microseconds into the VBLI scan lines of FIGS. 1A, 1B, 1C and 1D 127-sample PN sequences 14, 24, 34 and 44 respectively occur. Each of the PN sequences 14, 24, 34 and 44 is of the same 9-microsecond duration as the others. The PN sequence in the final field of each frame is of opposite polarity from the PN sequence in the initial field of that frame and is of the same polarity as the PN sequence in the initial field of the next frame, as indicated by the arrows associated with respective ones of the PN sequences 14, 24, 34 and 44. These PN sequences have −1 and +1 values at −15 IRE and +95 IRE levels respectively. These PN sequences have been specified to correspond as closely as possible to the DSRC system that has been officially tested; and design variations may be expected to occur should the compromise GCR signals described herein be adopted by the Subcommittee as their official recommendation for a standard.

There has been opinion within the Subcommittee that the Bessel pulse chirp should be shortened to 17 microsecond duration so ghosts of up to 40 microsecond delay can be cancelled without the restriction that the VBI line following that containing the GCR signal having not to have information therein that changes from field to field. If the Bessel pulse chirp is shortened, the PN sequence could be made to be 255 pulse sample times, rather than 127 pulse sample times, in length. Adjustments to the compromise GCR signals described herein may be made so the swings of the Bessel pulse chirp and the PN sequence correspond, with suitable adjustment of the gray pedestal, if appropriate. The inventors favor the chirp swing being increased to extend over the range between the −15 IRE and +95 IRE levels and the gray pedestal being set at 40 IRE. The lesser range for the chirps was chosen by the Philips engineers for fear of overswing under some conditions, but the inventors believe that i-f amplifier AGC will forestall such overswing. Extending the gray pedestal to the beginning of the PN sequence will then provide a signal that when low-pass filtered and subsequently gated during the mid-portion of the scan line will provide a level that is descriptive of 40 IRE level and can be used for automatic gain control of the composite video signal.

FIG. 2 shows the separated Bessel pulse chirp waveform that results when the GCR signals from two successive fields that are in two successive frames are differentially combined, assuming that the GCR signals are of the sort shown in FIGS. 1A, 1B, 1C and 1D. A separated Bessel pulse chirp waveform per FIG. 2 results when the GCR signals of FIGS. 1B and 1C are differentially combined. A separated Bessel pulse chirp waveform per FIG. 2 also results when the GCR signals of FIGS. 1D and 1A are differentially combined. A separated Bessel pulse chirp waveform per FIG. 2 also results when the sum of the GCR signals of FIGS. 1A and 1B is differentially combined with the sum of the GCR signals of FIGS. 1C and 1D.

FIG. 3 shows the waveform that results when the sum of the GCR signals of FIGS. 1A and 1D is differentially combined with the sum of the GCR signals of FIGS. 1B and 1C. The Bessel pulse chirp waveform, the "gray" pedestal and the chroma burst are supressed in this signal; and DC information concerning 0 IRE level is lost. The PN sequence is maintained as a separated PN sequence signal.

FIG. 4 shows in block schematic form a television transmitter for NTSC color television signals into which are inserted GCR signals per FIGS. 1A, 1B, 1C and 1D. A processing amplifier 50 generates composite video signals proceeding from color video signals and synchronizing signals. By way of example, the color video signals may be red (R), green (G) and blue (B) signals from a studio color camera and the synchronizing signals may be from a studio sync generator that also supplies synchronizing signals to the studio color camera. Alternatively, the color video signals may be from a remote location and the synchronizing signals furnished by a genlock connection. Or, if the local transmitter is a low-power transmitter re-broadcasting signals received over-the-air from a distant high-power transmitter, the color video signals may be generated by demodulating the received composite video signal and the synchronizing signals may be separated from the received composite video signal.

The processing amplifier 50 is shown as including a crystal oscillator 51 furnishing oscillations at eight times color carrier frequency f_c, a counter 52 for counting the number of these oscillations per horizontal scan line, a counter 53 for counting scan lines per field, and a counter 54 for counting modulo-four successive fields of video signal. The processing amplifier 50 supplies its composite video output signal as a first input signal to an analog selector switch 55. The output signal from the analog selector switch 55 is supplied to a video modulator 56 to control the vestigial-sideband amplitude modulation of the video carrier.

Sound signal is supplied to a frequency modulator 57. The modulated video and sound carriers are amplified by radio-frequency ampliers 58 and 59, respectively, and the output signals from the amplifiers 58 and 59 are combined in a coupling network 60 to a broadcast antenna 6D. A number of variants of the conventional television transmitter arrangements described in this and the previous paragraph are known to those familiar with television transmitter design.

The analog selector switch 55 corresponds to that previously known for inserting the vertical interval reference (VIR) signal. A decoder 62 detects those portions of the count from the counter 52 associated with the "active" portions of horizontal scan lines—i. a., the portions of horizontal scan lines exclusive of the horizontal blanking intervals—to generate a logic ONE. A decoder 63 responds to the scan line count from the counter 53 to decode the occurence of the 19^{th} scan line in each field and generate a logic ONE. An AND gate 64 responds to these logic ONEs occurring simultaneously to condition the analog selector switch 55 to select a second input signal for application to the video modulator 56, rather than the composite video signal furnished from the processing amplifier 50 to the analog selector switch 55 as its first input signal. This second signal is not the VIR signal, however, but is in successive fields successive ones of the GCR signals depicted in FIGS. 1A, 1B, 1C and 1D (or, alternatively, in FIGS. 7A, 7B, 7C and 7D).

These GCR signals are stored in digitized form in a read-only memory 65. A first portion of the address for the ROM 65 is supplied from the counter 54, the modulo-four field count selecting which of the GCR signals depicted in FIGS. 1A, 1B, 1C and 1D is to be inserted in the current field. A second portion of the address for the ROM 65 is supplied from the counter 52 and scans the selected one of the GCR signals depicted in FIGS. 1A, 1B, 1C and 1D. The digitized GCR signal read from the ROM 65 is supplied to a digita-to-analog converter 66. The resulting analog GCR signal is supplied as the second input signal to the analog selector switch 55 for insertion into the "active" portion of the 19^{th} line of the field.

FIG. 5 depicts a television receiver arranged to receive television signals incorporating the ghost cancellation reference signals of FIGS. 1A, 1B, 1C and 1D. Television signals collected by an antenna 70 are amplified by a radio-frequency amplifier 71 and then down-converted to an intermediate frequency by a converter 72. An intermediate-frequency amplifier 73 supplies to a video detector 74 and to a sound detector 75 amplified response to the intermediate-frequency signals from the converter 72. The sound detector 75 demodulates the frequency-modulated sound carrier and supplies the resulting sound detection result to audio electronics 76. The audio electronics 76, which may include stereophonic sound detection circuitry, includes amplifiers for supplying amplified sound-descriptive electric signals to loudspeakers 77 and 78.

The video detector 74 supplies analog composite video signal to an analog-to-digital converter 79, to a burst detector 80, to a horizontal sync separator 81 and to a vertical sync separator 82. The separated horizontal synchronizing pulses from the horizontal sync separator 81 and the separated vertical synchronizing pulses from the vertical sync separator 82 are supplied to kinescope deflection circuitry 83, which generates deflection signals for a kinescope 84. A burst gate generator 85 generates a burst gate signal an appropriate interval after each horizontal sync pulse it is supplied from the horizontal sync separator 81. This burst gate signal keys the burst detector 80 into operation during chroma burst interval. The burst detector 80 is included in a phase-locking loop for a phase-locked oscillator 86. The phase-locked oscillator 86 oscillates at a frequency sufficiently high that the analog-to-digital converter 79 sampling the analog composite video signal from the video detector 74 once with each oscillation oversamples that signal. As is well-known, it is convenient from the standpoint of simpler digital hardware design that phase-locked oscillator 86 oscillate at a frequency that is an integral power of two greater than the 3.58 MHz color subcarrier frequency. Sampling chroma signals four or eight times per cycle is preferred.

The separated horizontal sync pulses from the horizontal sync separator 81 are supplied to a scan line counter 87 for counting, the scan line count from which counter 87 is reset to zero at the outset of each vertical sync interval by separated vertical sync pulses from the vertical sync separator 82. Indication in the count from the counter 87 of the occurence of the 19^{th} scan line in each field is detected by a decoder 88. Indication in the count from the counter 87 of the occurence of the 20^{th} scan line in each field is detected by a decoder 89. The occurences of the 19^{th} and 20^{th} scan lines in each field is signaled to a GCR signal capture processor 90, which captures the GCR signals in the 19^{th} scan line of each field of digital composite video signal from the analog-to-digital converter 79.

This capturing process will be described in greater detail in connection with the description of FIG. 6.

The GCR signal capture processor 90 includes circuitry for separating the Bessel pulse chirp portion of the captured GCR signals, which portion is supplied to a ghost-cancellation filter weight computer 91. The GCR signal capture processor 90 also includes circuitry for separating the PN sequence portion of the captured GCR signals, which portion is supplied to an equalization filter weight computer 92. The digitized composite video signal from the analog-

to-digital converter **79** is supplied via a cascade connection of a ghost-cancellation filter **93** and an equalization filter **94** to a luma/chroma separator **96**. The ghost-cancellation filter **93** has filtering weights adjustable in response to results of the computations by the ghost-cancellation filter weight computer **91**, and the equalization filter **94** has filtering weights adjustable in response to results of the computations by the equalization filter weight computer **92**.

The ghost-cancellation filter weight computer **91** is preferably of a type in which the Discrete Fourier Transform (DFT) of the ghosted GCR signal is divided by the DFT of the non-ghosted GCR signal to obtain as a quotient the DFT transform of the transmission medium giving rise to ghosting; and the inverse DFT of this quotient is then used to define the filter weighing coefficients of a compensating ghost-cancellation filter. As known by those skilled in the ghost-cancellation art, the ghost-cancellation filter **93** is preferably of a type with a sparse kernel where the positioning of the non-zero filter weights can be shifted responsive to results from the ghost-cancellation filter weight computer **91**. A ghost-cancellation filter with a dense kernel would typically require **2048** filter weights, which woud be difficult to construct in actual practice.

The equalization filter weight computer **92** could be of a type performing calculations using DFTs, the results of which are subject to inverse-DFT in order to define the filter weighing coefficients of a compensating equalization filter **94**. Preferably, however, the equalization filter weight computer **92** is of a type using a least-mean-square error method to perform an iterative adjustment of a 15-tap or so digital FIR filter used as the equalization filter **94**, adjustment being made so that there is a best match to the (sin x)/x function of the result of correlating of a portion of the de-ghosted PN sequence with the corresponding portion of the PN sequence known at the receiver as being a standard.

The luma/chroma separator **95** is preferably of a type using digital comb filtering for separating a digital luminance signal and a digital chroma signal from each other, which signals are respectively supplied to digital luminance processing circuitry **96** and to digital chrominance processing circuitry **97**. The digital luminance (Y) signal from the digital luminance processing circuitry **96** and the digital I and Q signals from the digital chrominance processing circuitry **97** are supplied to a digital color matrixing circuit **98**. Matrixing circuit **98** responds to the digit Y. I and Q signals to supply digital red (R), green (G) and blue (B) signals to digital-to-analog converters **99**, **100** and **101**, respectively. Analog red (R), green (G) and blue (B) signals are supplied from the digital-to-analog converters **99**, **100** and **101** to R, G and B kinescope driver amplifiers **102**, **103** and **104**, respectively. R, G and B kinescope driver amplifiers **102**, **103** and **104** supply red (R), green (G) and blue (B) drive signals to the kinescope **84**.

The filter **94** has thusfar been termed an "equalization filter" and considered to be a filter that would provide a flat frequency response through the band, which is the way this filter has been characterized by other workers in the ghost-cancellation art. In practice it is preferable to adjust the filter weights in the filter **94** not for flat frequency response through the band but with a frequency response known to provide some transient over- and under-shooting, or video peaking. This reduces the need for

providing transient overshooting or video peaking in the digital luma processing circuitry **96**.

FIG. **6** shows a representative way of constructing the GCR signal capture processor **90**. Random access memories **111**, **112**, **113** and **114** are arranged to serve as line stores for the GCR reference signals supplied during fields **00**, **01**, **10** and **11** of each cycle of four successive fields of digitized composite video signal.

These GCR reference signals are supplied to the respective input ports of the RAMs **111**, **112**, **113** and **114** from the analog-to-digital converter **79**. The four successive fields in each cycle are counted modulo-4 by a two-stage binary counter **115** that counts the ONEs generated by a decoder **116** that detects indications of the last scan line in a field furnished by the scan line count from the counter **87**. As a preparatory measure in the procedure of updating the filter weighting coefficients in the ghost-cancellation filter **93** and in the equalization filter **94**, the proper phasing of the modulo-**4** field count can usually be determined by correlating the most recently received GCR signal, as de-ghosted, with each of the four standard GCR signals stored in the receiver, looking for best match. Decoders **121**, **122**, **123** and **124** decode the **100**, **101**, **110** and **111** signals as generated by the 19^{th} line decoder **88** supplying most significant bit and field count from the field counter **115** supplying the two less significant bits, thereby to furnish write enable signals sequentially to the RAMs **111**, **112**, **113** and **114** during the 19^{th} scan lines of successive fields.

The RAMs **111**, **112**, **113** and **114** are addressed in parallel by an address counter **125** that counts the number of samples per scan line. The address counter **125** receives the oscillations from the phase-locked oscillator **86** at its count input connection, and is reset by an edge of the horizontal sync pulse. This addressing scan during the 19^{th} scan line allocates each successive digital composite video signal sample to a successive addressable location in the one of the RAMs **111**, **112**, **113** and **114** receiving a write enable signal. During the 20^{th} scan line the decoder **89** provides a read enable signal to all of the RAMs **111**, **112**, **113** and **114**. The addressing scan the counter **125** provides the RAMs **111**, **112**, **113** and **114** during the 20^{th} scan line reads out the four most recently received and stored GCR signals parallely to a serial processor **126** that combines them to generate sequential samples of a separated Bessel pulse chirp signal and sequential samples of a separated PN sequence.

During the 20^{th} scan line, the decoder **89** also provides a write enable signal to RAMs **127** and **128** that respectively serve as line stores for the separated chirp signal and separated PN sequence.

The decoder **89** at the same time conditions address multiplexers **129** and **130** to select addresses from the address counter **125** as write addressing for the RAMs **127** and **128** respectively. The counter **125** provides the RAM **127** the addressing scan needed to write thereinto the sequential samples of the separated chirp signal from the serial processor **126**. The counter **125** also provides the RAM **128** the addressing scan needed to write thereinto the sequential samples of the separated PN sequence from the serial processor **126**. At times other than the 20^{th} scan line, the address multiplexer **129** selects to the RAM **127** read addressing supplied from the ghost-cancellation filter weight computer **91** during data fetching operations, in which operations the computer **91** also supplies the RAM **127** a read enable signal. At times other than the 20^{th} scan line, the address multiplexer **130** selects to the RAM **128** read addressing supplied from the equalization filter weight computer **92** during data fetching operations, in which operations the computer **92** also supplies the RAM **128** a read enable signal.

FIGS. **7A**, **7B**, **7C** and **7D** are waveforms of the ghost cancellation reference signals in selected vertical blanking

intervals of four successive fields of video, as embody the invention in one of its aspects, alternative to the aspect of the invention which FIGS. 1A, 1B, 1C and 1D concern. The GCR signals in FIGS. 7A and 7D are the same as those of FIGS. 1A and 1D. The GCR signals in FIGS. 7B and 7C differ from those of FIGS. 1B and 1C in that the swings of the PN sequences are reversed in direction. In FIGS. 7B and 7C the swings of the PN sequences **24'** and **34'** are in the same direction as the swings of the PN sequences **14'** and **44'** in FIGS. 7A and 7D.

FIG. **8** shows the separated Bessel pulse chirp waveform that results when the GCR signals from two successive fields that are in two successive frames are differentially combined, assuming that the GCR signals are of the sort shown in FIGS. 7A, 7B, 7C and 7D. A separated Bessel pulse chirp waveform per FIG. **8** results when the GCR signals of FIGS. 7B and 7C are differentially combined. A separated Bessel pulse chirp waveform per FIG. **8** also results when the GCR signals of FIGS. 7D and 7A are differentially combined. A separated Bessel pulse chirp waveform per FIG. **8** also results when the sum of the GCR signals of FIGS. 7A and 7B is differentially combined with the sum of the GCR signals of FIGS. 7C and 7D.

FIG. **9** shows the waveform that results when the GCR signals from four (or any multiple of four) successive fields are additively combined or are averaged, assuming that the GCR signals are of the sort shown in FIGS. 7A, 7B, 7C and 7D. The Bessel pulse chirp waveform and the chroma burst are suppressed in this signal. The DC level and "gray" pedestal are maintained in this signal as well as the PN sequence. The PN sequence can then be separated by high-pass digital filtering. The DC level and "gray" pedestal can be separated by low-pass digital filtering. The DC level and "gray" pedestal are useful in circuitry for controlling the gain and DC-offset of the analog composite signal applied to the analog-to-digital converter **79**. Circuits are known in the prior art in which the digital output signal of an analog-to-digital converter is selected as input signal to a first digital comparator during a portion of the digitized composite video signal known to be supposedly at 0 IRE level, there to be compared against digitized ideal 0 IRE level to develop a first digital error signal that is converted to analog error by a digital-to-analog converter and fed back to degenerate error in the 0 IRE level against which the input signal to the analog-to-digital converter is DC-restored. In certain of these circuits the digital output signal of the same analog-to-digital converter is selected as input signal to a second digital comparator during a portion of the digitized composite video signal known to be supposedly at a prescribed pedestal level, there to be compared against the prescribed pedestal level in digital form to develop a second digital error signal that is converted to analog error by a digital-to-analog converter and fed back as an automatic gain control (AGC) signal to a gain-controlled amplifier preceding the analog-to-digital converter and keeping the input signal to the analog-to-digital converter quite exactly within the bounds of the conversion range.

FIG. **10** shows how the FIG. **6** serial processor may be constructed for processing the ghost cancellation reference signals of FIGS. 1A, 1B, 1C and 1D to generate the FIG. **2** and FIG. **3** signals. A serial adder **131** sums the RAM **111** output signal per FIG. 1A with the RAM **112** output signal per FIG. 1B. A serial adder **132** sums the RAM **113** output signal per FIG. 1C with the RAM **114** output signal per FIG. 1D. A serial subtractor **133** subtracts the sum output of the adder **132** from the sum output of the adder **131** to generate a separated Bessel pulse chirp signal.

With a bit point shift of two places towards less significance, for carrying out wired division by four, this separated Bessel pulse chirp signal is the FIG. **2** signal. A serial adder **134** sums the RAM **111** output signal per FIG. 1A with the RAM **114** output signal per FIG. 1D. A serial adder **135** sums the RAM **112** output signal per FIG. 1B with the RAM **113** output signal per FIG. 1C. A serial subtractor **136** subtracts the sum output of the adder **135** from the sum output of the adder **134** to generated a separated PN sequence signal. With a bit point shift of two places towards less significance, for carrying out wired division by four, this separated PN sequence signal is the FIG. **3** signal.

FIG. **11** shows how the FIG. **6** serial processor may be constructed for processing the ghost cancellation reference signals of FIGS. 7A, 7B, 7C and 7D to generate the FIG. **8** and FIG. **9** signals. Serial adders **131** and **132** and serial subtractor **133** cooperate to generate a separated Bessel pulse chirp signal, as described in connection with FIG. **10**. With a bit point shift of two places towards less significance, for carrying out wired division by four, this separated Bessel pulse chirp signal is the FIG. **8** signal. A serial adder **137** sums the sum outputs of the adders **131** and **132** to generate a separated PN sequence signal. With a bit point shift of two places towards less significance, for carrying out wired division by four, this separated PN sequence signal is the FIG. **9** signal.

One skilled in the art of electronic circuits and systems design and acquainted with the foregoing disclosure will be enabled to design a number of variants of the signals and circuits specifically disclosed; and this should be borne in mind when considering the respective scopes of the claims which follow.

What is claimed is:

1. A communication system comprising:

means for generating video signals;

means for inserting ghost canceling reference signals in each vertical blanking interval of said video signals, said ghost canceling reference signals comprising pseudo-noise (PN) sequences and chirp signals of different predefined signal characteristics;

transmission means for enabling transmission of said video signals containing said ghost canceling reference signals; and

ghost canceling means for enabling reception of said video signals containing said ghost canceling reference signals transmitted by said transmission means and processing said ghost canceling reference signals contained in said received video signals to eliminate channel transmission delay distortion.

2. A composite ghost-cancellation reference signal included within a single scan line of a television signal, said composite ghost cancellation reference signal adapted for deghosting said television signal and comprising a first ghost-cancellation reference signal having a fist time duration and a second ghost-cancellation reference signal a second time duration shorter than said first time duration, wherein said second ghost-cancellation signal comprises a pseudo-noise sequence.

3. A method for de-ghosting television signals transmitted in cyclic fields having a plurality of lines, said method comprising:

transmitting in one of said lines a composite ghost-cancellation reference signal comprising a first ghost-cancellation reference signal having a first time duration and a second ghost-cancellation reference signal having a second time duration shorter than said first

time duration wherein said second ghost-cancellation reference signal comprises a pseudo-noise sequence;

receiving said composite ghost-cancellation reference signal in said one of said lines; and

de-ghosting said television signal using at least one of said first ghost-cancellation reference signal or said second ghost-cancellation reference signal.

4. The method of claim 3 wherein said first ghost-cancellation reference signal comprises a chirp signal.

5. A receiver for receiving television signals and de-ghosting said television signals using a composite ghost-cancellation reference signal, said composite ghost-cancellation signal included within a single scan line of a television signal and comprising a first ghost-cancellation reference signal having a first time duration and a second ghost-cancellation reference signal having a second time duration shorter than said first time duration, wherein said second ghost-cancellation signal comprises a pseudo-noise sequence.

6. The receiver of claim 5 wherein said first ghost-cancellation reference signal comprises a chirp signal.

7. A method for de-ghosting television signals transmitted in cyclic fields having a plurality of lines, said method comprising:

receiving in one of said lines a composite ghost-cancellation reference signal comprising a first ghost-cancellation reference signal having a fist time duration and a second ghost-cancellation reference signal having a second time duration shorter than said first time duration, wherein said second ghost-cancellation reference signal comprises a pseudo-noise sequence; and

de-ghosting said television signal using at least one of said first ghost-cancellation reference signal or said second ghost-cancellation reference signal.

8. The method of claim 7 wherein said first ghost-cancellation reference signal comprises chirp signal.

9. An apparatus for receiving a ghost-cancellation reference signal included within a composite video signal, said apparatus adapted to de-ghost the composite video signal using the ghost-cancellation reference signal, said ghost-cancellation reference signal including within an active portion of each of selected scan lines both a chirp signal and a pseudo noise sequence.

10. An apparatus for receiving a ghost-cancellation reference signal included within a composite video signal, said apparatus adapted to de-ghost the composite video signal using the ghost-cancellation reference signal, said ghost-cancellation reference signal including within an active portion of a single scan lines in each vertical blanking interval both a chirp signal and a pseudo noise sequence, wherein within each said single scan line in each vertical blanking interval said chirp signal precedes said pseudo noise sequence.

11. The apparatus as set forth in claim 9, wherein within each said selected scan line said chirp signal precedes said pseudo noise sequence.

12. The apparatus as set forth in claim 11, wherein in each pair of successive pairs of said selected scan lines both scan lines have respective chirp signals of the same sense as each other, and wherein within each said pair of selected scan lines the two scan lines have respective pseudo noise sequences of opposite sense to each other.

13. The apparatus as set forth in claim 12, wherein within each said pair of selected scan lines the two scan lines respected color bursts of opposite sense to each other.

14. The apparatus as set forth in claim 13, wherein the two selected scan lines in each succeeding said pair of selected scan lines have respective chirp signals of opposite sense to the respective chirp signals in the preceding said pair of selected scan lines.

15. The apparatus as set forth in claim 12, wherein successive ones of said selected scan lines occur in respective vertical blanking intervals of said composite video.

16. The apparatus as set forth in claim 15, wherein successive ones of said selected scan lines occur in successive vertical blanking intervals of said composite video signal.

17. The apparatus as set forth in claim 15, wherein within each said pair of selected scan lines the two scan lines have respective color burst of opposite sense to each other.

18. The apparatus as set forth in claim 17, wherein the two selected scan lines in each succeeding said pair of selected scan lines have respective chirp signals of opposite sense to the respective chirp signals in the preceding said pair of selected scan lines.

19. The apparatus as set forth in claim 16, wherein the two selected scan lines in each succeeding said pair of selected scan lines have respective chirp signals of opposite sense to the respective chirp signals in the preceding said pair of selected scan lines.

20. The apparatus as set forth in claim 9 wherein a prescribed scan line in each vertical blanking interval corresponds to a respective one of said selected scan lines.

21. The apparatus as set forth in claim 20, wherein within each said selected scan line said chirp signal precedes said pseudo noise sequence, wherein in each pair of successive pairs of said selected scan lines both scan lines have respective signals of same sense as each other, and wherein within each said pair of selected scan lines the two scan lines have respective pseudo noise sequences of opposite sense to each other.

22. The apparatus as set forth in claim 21, wherein within each said pair of selected scan lines the two scan lines have respected color burns of opposite sense to each other.

23. The apparatus as set forth claim 22, where the two selected scan lines in each succeeding said pair of selected scan lines have respective chirp signals of opposite sense to the respective chirp signals in the preceding said pair of selected scan lines.

24. The apparatus as set forth in claim 9, wherein in each pair of successive pairs of said selected scan lines both scan lines have respective pseudo noise sequences of the same sense as each other, and wherein with each said pair of selected scan lines the two scan lines have chirp signals of opposite sense to each other.

25. An apparatus for receiving a ghost-cancellation reference signal included within a composite video signal, said apparatus adapted to de-ghost the composite video signal using the ghost-cancellation reference signal, said ghost-cancellation reference signal including within an active portion of a single scan line in each vertical blanking interval both a chirp signal and a pseudo noise sequence.

26. An apparatus for receiving a composite ghost-cancellation reference signal included within a single scan line of a television signal, said apparatus adapted to de-ghost the composite video signal using the composite ghost-cancellation reference signal, said composite ghost cancellation reference signal comprising a first ghost-cancellation reference signal having a first time duration and a second ghost-cancellation reference signal having a second time duration shorter than said first time duration, wherein said second ghost-cancellation signal comprises a pseudo-noise sequence.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,937,292 B1
DATED : August 30, 2005
INVENTOR(S) : Patel et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 11,
Lines 5 and 32, cancel "signal" and insert -- signals --.

Column 12,
Line 13, cancel "burst" and insert -- bursts --.
Line 37, cancel "burns" and insert -- bursts --.

Signed and Sealed this

Twenty-first Day of March, 2006

JON W. DUDAS
Director of the United States Patent and Trademark Office

EXHIBIT 4

US006104436A

United States Patent [19]

Lee

[11] **Patent Number: 6,104,436**

[45] **Date of Patent: Aug. 15, 2000**

[54] **METHOD AND APPARATUS FOR DISPLAYING SUBCHANNEL INFORMATION IN A DIGITAL TV RECEIVER**

[75] Inventor: **Hyoung-Joo Lee**, Seoul, Rep. of Korea

[73] Assignee: **Samsung Electronics Co., Ltd.**, Suwon, Rep. of Korea

[21] Appl. No.: **09/033,006**

[22] Filed: **Mar. 2, 1998**

[30] **Foreign Application Priority Data**

Jun. 30, 1997 [KR] Rep. of Korea 97-29926

[51] **Int. Cl.**[7] **H04N 5/445**

[52] **U.S. Cl.** **348/563**; 348/569

[58] **Field of Search** 348/569, 906, 348/563, 564; H04N 5/445, 5/50

[56] **References Cited**

U.S. PATENT DOCUMENTS

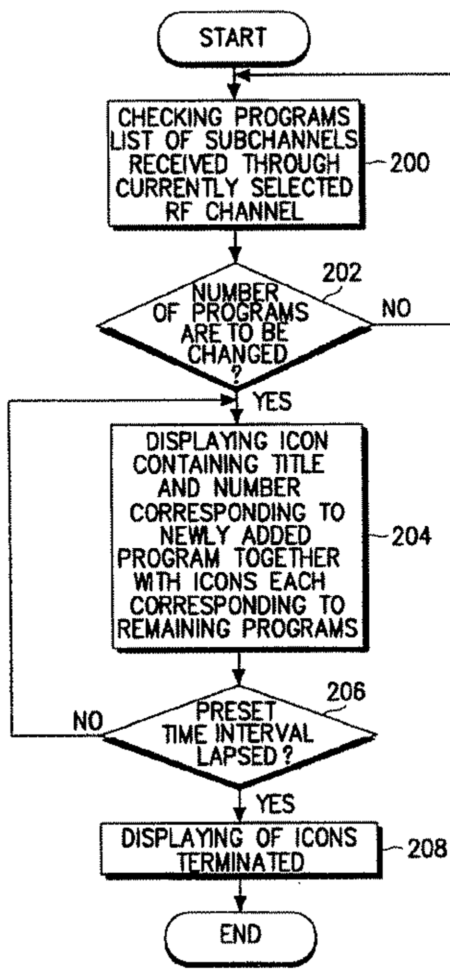
5,786,869 7/1998 Baek 348/565

Primary Examiner—Sherrie Hsia
Attorney, Agent, or Firm—Staas & Halsey LLP

[57] **ABSTRACT**

A method and apparatus for use in a digital multichannel television (TV) receiver and for displaying subchannel information, such that the method includes the steps of detecting the list of broadcasting programs of the subchannels of a currently selected RF channel to check whether the number of the programs are changed, and displaying the information about newly added programs on the TV screen when the number of the programs are changed. When a new program is added, a corresponding icon displayed on a screen of the digital multichannel TV receiver includes a title and/or a channel (program) number of the newly added program.

16 Claims, 3 Drawing Sheets



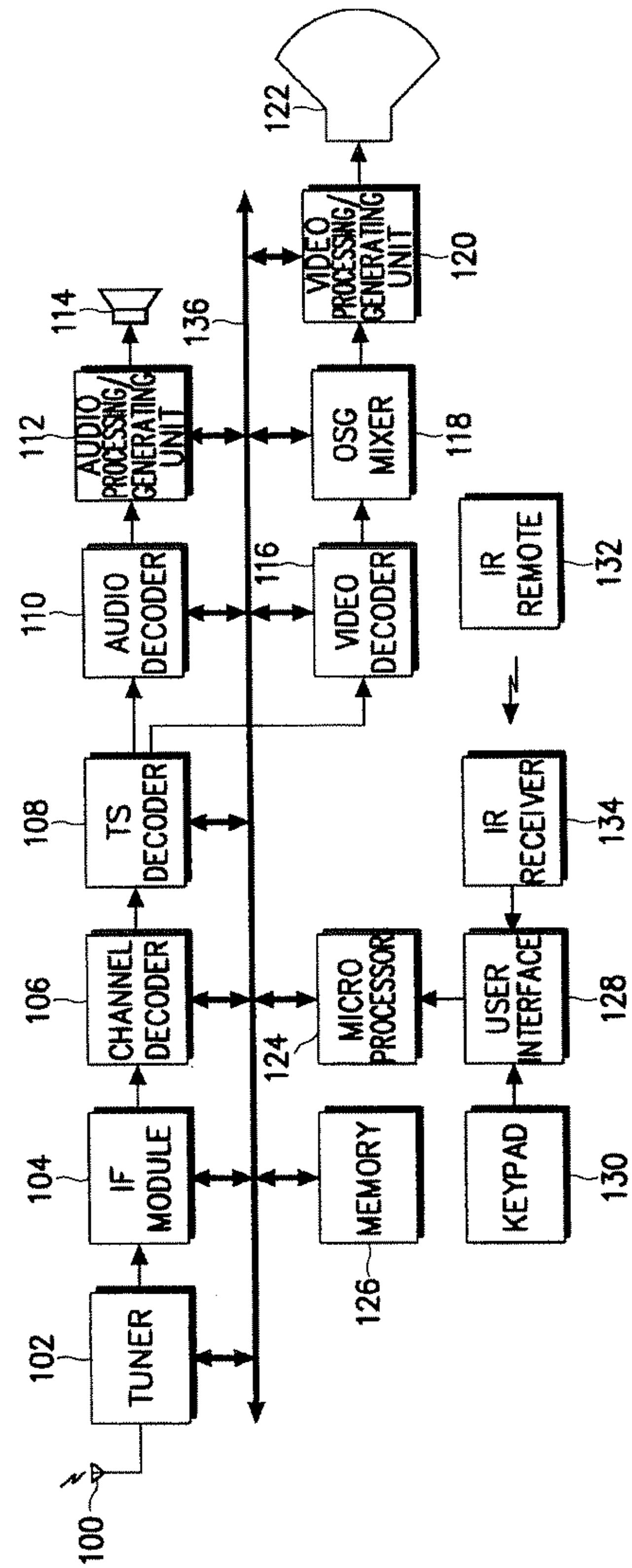
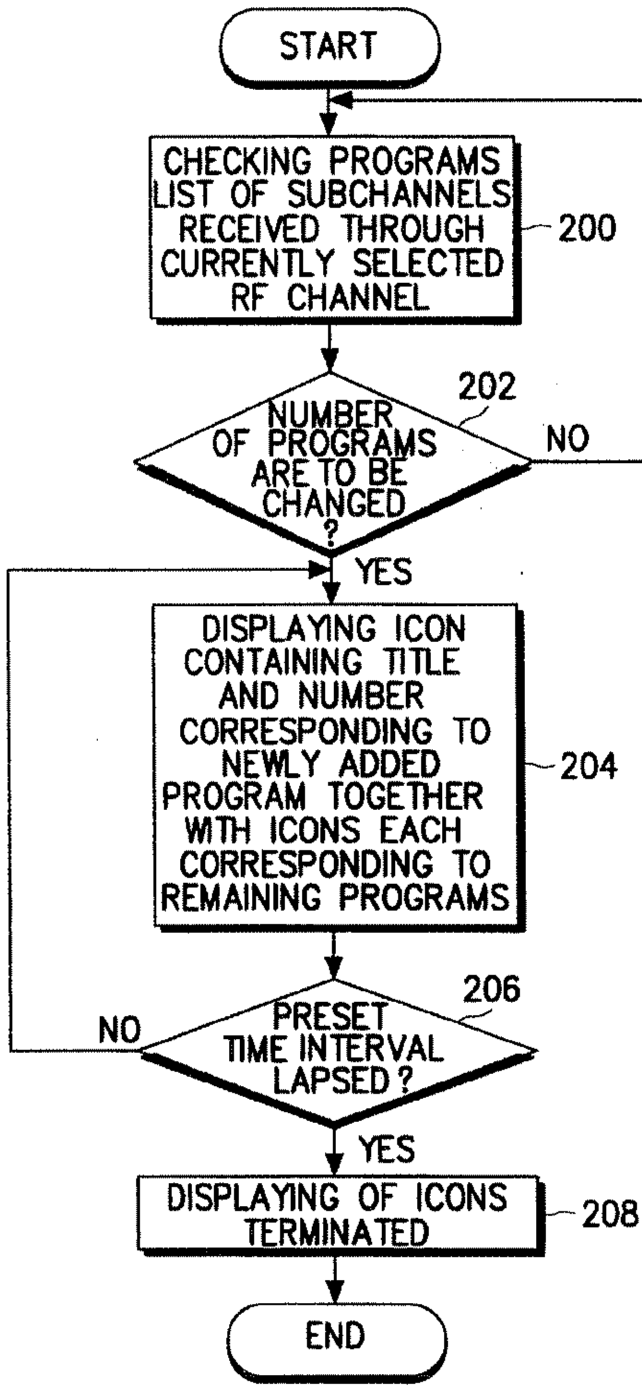

100
102
TUNER
104
IF MODULE
106
CHANNEL DECODER
108
TS DECODER
110
AUDIO DECODER
112
AUDIO PROCESSING/ GENERATING UNIT
114
136
116
VIDEO DECODER
118
OSG MIXER
120
VIDEO PROCESSING/ GENERATING UNIT
122
124
MICRO PROCESSOR
126
MEMORY
128
USER INTERFACE
130
KEYPAD
132
IR REMOTE
134
IR RECEIVER

FIG. 1



START
CHECKING PROGRAMS LIST OF SUBCHANNELS RECEIVED THROUGH CURRENTLY SELECTED RF CHANNEL
200
202
NUMBER OF PROGRAMS ARE TO BE CHANGED ?
NO
YES
DISPLAYING ICON CONTAINING TITLE AND NUMBER CORRESPONDING TO NEWLY ADDED PROGRAM TOGETHER WITH ICONS EACH CORRESPONDING TO REMAINING PROGRAMS
204
206
PRESET TIME INTERVAL LAPSED ?
NO
YES
DISPLAYING OF ICONS TERMINATED
208
END

FIG. 2

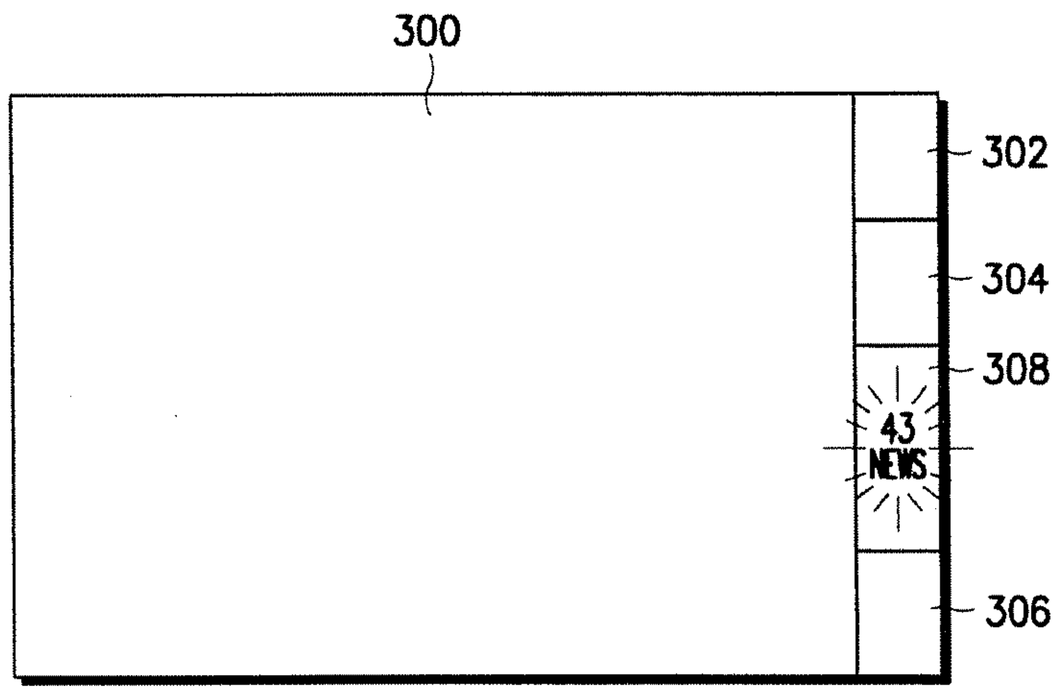


FIG. 3

METHOD AND APPARATUS FOR DISPLAYING SUBCHANNEL INFORMATION IN A DIGITAL TV RECEIVER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a digital TV set for receiving a multichannel television signal, and more particularly, to a method and apparatus for displaying channel information on a TV screen.

2. Description of the Related Art

In analog TV broadcasting such as an NTSC (National Television System Committee) system, only one program can be transmitted through a specified frequency band of an RF channel.

On the contrary thereto, in a digital TV broadcasting system for a next generation system such as an HDTV (High Definition TV), the number of RF channels is much greater than in the analog TV broadcasting system. Furthermore, the bit rate required can be allocated to a needed service when necessitated. That is, a plurality of programs can be transmitted over a limited transmission bandwidth of an RF channel. For example, the existing standard definition television (SDTV) programs such as analog TV broadcast can be planned on multichannels for a period of time, and the HDTV programs on a single channel for another time zone. Such an example is referred to as the ATSC (United States Advanced Television System Committee) Standard. According to the ATSC standard, it is recommended that subchannels of at least one HD program plus six SD programs at a maximum can be broadcast on an RF channel corresponding to an existing analog channel.

Besides, the number of subchannel programs transmitted through each RF channel can be also changed while a user is watching TV. For example, a TV broadcast with three SD programs can be additionally added by a further SD program, thereby being changed to a TV broadcast with four SD programs, and on the contrary, to a single HD program. For reference, since it hardly ever occurs that several programs are simultaneously added or terminated, it is assumed in most cases that one or another program is added or cancelled.

As described above, since multiple programs can be broadcast on a single RF channel in the digital multichannel TV broadcasting, in which the number of programs can be changed at any time, it is necessary to display program guide information on the screen of a digital TV set, so that user can select one from among several programs. For this purpose, the ATSC standard provides for a unique electronic program guide (EPG) for program selections. That is, TV broadcast stations transmit EPG information on every RF channel, and digital TV sets receive and store the EPG information so as to display it on a screen when requested by user.

The user can check the list of programs transmitted through subchannels of a certain RF channel by means of such EPG information, but the user must check an extra EPG information screen for that purpose. Therefore, when programs of subchannels are changed, a user can not be immediately advised thereof.

As aforementioned, it is a drawback of the prior art that a user misses useful desired programs because the user can not be immediately informed of changed programs of subchannels in digital multichannel TV broadcasting.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a subchannel information displaying method capable of furnishing a user with information about a program change of subchannels during the watching of a digital television.

Additional objects and advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

According to the present invention, a method for displaying subchannel information comprises the steps of detecting the list of broadcasting programs of the subchannels of a currently selected RF channel to check whether the number of the programs has changed, and displaying the information about newly added programs on a TV screen when the number of the programs has changed.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described more specifically with reference to the drawings attached only by way of example.

FIG. **1** is a block diagram of an HDTV receiver as a digital TV set adopting the MPEG (Moving Picture Expert Group) standard according to an embodiment of the present invention;

FIG. **2** is a process flow chart of the embodiment to be applied to the HDTV receiver as the digital TV set according to the embodiment of the present invention; and

FIG. **3** is a descriptive diagram of a TV screen displaying program information of channels based upon a program change according to the embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference will now made in detail to the present preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. The embodiments are described below in order to explain the present invention by referring to the figures.

Referring to FIG. 1, a tuner **102** selects one RF channel among broadcasting signals received through an antenna **100** under the control of a microprocessor **124**. Thereupon, the tuner **102** outputs an IF (intermediate frequency) signal of the selected channel, which is converted by the IF module **104** into a baseband signal so as to then be delivered to a channel decoder **106**. The channel decoder **106** converts the baseband signal to a channel signal to reconstruct data bit strings. Such reconstructed data bit strings are separated into audio data, video data, and auxiliary data by a TS (transport stream) decoder **108**.

The above audio data are delivered to an audio decoder **110** so as to be decoded in accordance with the MPEG standard or the Dolby AC-3 standard, whereupon the resulting signals are processed by an audio processing/generating unit **112** so as to be output as audible sound through a speaker **114**. Besides, the video data are delivered to a video decoder **116** so as to be decoded in accordance with the MPEG standard, whereby the resulting signal is applied to an OSG (On Screen Graphic) mixer **118** to be mixed with OSG data under the control of the microprocessor **124** and then processed by a video processing/generating unit **120**. The video processed data is being displayed on a screen **122** through a picture tube. The OSG data are used for displaying various information in the form of graphic and text on the screen **122** under the control of the microprocessor **124**.

The microprocessor **124**, as the controller of the HDTV set, is connected with a keypad **130** and an IR (infrared)

receiver **134** through a user interface **128**. The microprocessor **124** performs operations based on commands input from the keypad **130** and the IR remote **132** via the IR receiver **134** according to a program stored in the memory **126**. The IR remote **132** is a cordless mouse, such as an air mouse, or a remote controller. The commands input from the IR remote **132** are transmitted in the form of an IR signal to the IR receiver **134** to be applied to the microprocessor **124** through a user interface **128**. Further, the microprocessor **124** receives the auxiliary data from the TS decoder **108**, whereby such auxiliary data contain the program specification information (PSI) as the table containing program related information stipulated by the MPEG2 standard, and/or the above-mentioned EPG information, etc.

The memory **126** includes a ROM (Read Only Memory) for storing the program of the microprocessor **124**, a RAM (Random Access Memory) for temporarily storing data resulting from the program execution of the microprocessor **124**, and an EEPROM (Electrically Erasable and Programmable ROM) for storing various reference data.

The above tuner **102**, IF module **104**, channel decoder **106**, TS decoder **108**, audio decoder **110**, audio processing/generating unit **112**, video decoder **116**, OSG mixer **118**, video processing/generating unit **120**, and memory **126** are connected with the microprocessor **124** through a bus **136**.

The operations according to the process flow chart as shown in FIG. **2** are programmed and stored in the memory **126** so as to be performed by the microprocessor **124** of FIG. **1**.

Referring to FIGS. **1** and **2**, in steps **200–202**, the microprocessor **124** checks whether the number of programs are to be changed by checking the program specification information or the EPG information contained in auxiliary data supplied from the TS decoder **108** for a programs list of subchannels received through the RF channel currently selected, and when the number of programs are changed, the microprocessor **124** proceeds to step **204**.

In step **204**, the microprocessor **124** displays icons including titles and numbers of newly added programs together with icons corresponding to remaining programs respectively on the screen by means of the OSG mixer **118**.

FIG. **3** illustrates a TV screen displaying an icon **308** corresponding to a newly added program together with icons corresponding to the remaining existing programs **302–306** independent of the main screen **300**, assuming that the title of the newly added program is "news" and the program number is "43". The icons **302–308** are displayed by arranging the icons **302–308** in numerical order of the program numbers, and only the icon corresponding to a newly added program is blinking so as to be distinguished from the remaining existing icons **302–306**. Thus, when the programs of the subchannels are changed while the user is watching TV, the user can be immediately informed thereof.

As described above, after starting to display program information and icons **302–308** according to the program change, the microprocessor **124** checks in step **206** whether a preset time interval has lapsed, and terminates the display of the icons **302–308** in step **208** when the preset time interval is lapsed.

Although the present invention has been described with reference to a concrete embodiment, it will be noted that various modifications may be made without departing the gist of the present invention. Particularly, the above embodiment of the present invention shows an example with respect to an HDTV receiver, but the present invention can be applied to all the digital multichannel TV receivers. According to the above embodiment, when a new program is added, the corresponding icon displayed on the screen includes both the title and the channel (program) number of the newly added program, but it is also possible to display the icon containing either the title or the program number. Therefore, the scope of the present invention must be determined by the appended claims covering all such changes and modifications which fall within the true spirit and scope of the present invention.

As described above, the present invention has the advantage that when programs of subchannels are changed while the user is watching TV, the user can be immediately informed thereof and conveniently watch available TV programs.

What is claimed:

1. A method of displaying subchannel information of subchannels of a currently selected RF channel on a television (TV) screen, comprising the steps of:
   - detecting a list of broadcasting programs of the subchannels of the currently selected RF channel, and checking whether a total number of the broadcasting programs are changed; and
   - displaying the subchannel information about newly added broadcasting programs to the currently selected RF channel on the TV screen when the total number of the broadcasting programs are changed.

2. The method of displaying subchannel information as claimed in claim **1**, wherein said displaying step comprises the step of displaying an icon corresponding to a title of the newly added program on the TV screen.

3. A method for displaying subchannel information as claimed in claim **1**, wherein said displaying step comprises the step of displaying an icon corresponding to a program number of each newly added broadcasting program on the TV screen.

4. The method of displaying subchannel information as claimed in claim **3**, wherein said displaying step comprises the steps of:
   - displaying the icon corresponding to each newly added broadcasting program together with icons corresponding to all the respective remaining broadcasting programs on the TV screen; and
   - blinking only the icon corresponding to each newly added broadcasting program.

5. The method of displaying subchannel information as claimed in claim **4**, wherein said step of displaying the icon corresponding to each newly added program together with icons corresponding to all the respective remaining broadcasting programs comprises the step of displaying the icons on the TV screen by arranging the icons in numerical order corresponding to the program numbers of the broadcasting programs.

6. The method of displaying subchannel information as claimed in claim **5**, further comprising the step of terminating the displaying step of the icons when a preset time interval has lapsed after starting the display of the icons.

7. A method of displaying subchannel information of subchannels of a currently selected RF channel on a television (TV) screen, comprising the steps of:
   - determining a list of broadcasting programs of the subchannels of the currently selected RF channel;
   - checking whether any change occurs in the list of broadcasting programs; and
   - displaying information on each of the broadcasting programs remaining in the list of broadcasting programs on the TV screen in response to any change occurring the list of broadcasting programs.

8. The method as claimed in claim 7, wherein said displaying information step comprises the steps of:

displaying icons corresponding to the remaining broadcasting programs on the TV screen; and

blinking the icon of each newly added broadcasting program in the list.

9. The method as claimed in claim 7, wherein each icon includes at least one of a title and a program number of the corresponding broadcasting program.

10. The method as claimed in claim 7, wherein said displaying information step comprises the step of displaying the information on each of the remaining broadcasting programs on the TV screen, while simultaneously displaying one of the remaining broadcasting programs on the TV screen.

11. A television (TV) receiver to receive a digital RF channel having a plurality of subchannels, and including a TV screen to display information indicative of the subchannels, the TV receiver comprising:

a decoding unit to decode the digital RF channel including the plurality of subchannels, to generate decoded RF channel data and a list of broadcasting programs of the subchannels; and

a processor to determine a change in the list of the broadcasting programs and to display the information of each newly added broadcasting program to the list in response to the change in the list.

12. The TV receiver as claimed in claim 11, wherein said processor displays icons of each of the broadcasting programs remaining in the list, including each newly added broadcasting program, on the TV screen.

13. The TV receiver as claimed in claim 12, wherein said processor blinks the icon of each newly added broadcasting program on the TV screen.

14. The TV receiver as claimed in claim 11, wherein said processor simultaneously displays the information of each newly added broadcasting program with one of the broadcasting programs on the TV screen.

15. The TV receiver as claimed in claim 11, wherein said decoding unit comprises:

a tuner to select the digital RF channel, and in response, generates an intermediate frequency signal;

an IF modulate to convert the intermediate frequency signal to a baseband signal;

a channel decoder to convert the baseband signal to a channel signal having data bit strings; and

a transport stream decoder to separate the data bit strings into video data and auxiliary data including the list of the broadcasting programs;

said transport stream decoder transmitting the auxiliary data to said processor.

16. The TV receiver as claimed in claim 15, further comprising an On Screen Graphic (OSG) mixer to mix OSG data with the video data, under control of said processor, to display the information of each newly added broadcasting program to the list.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,104,436
DATED : August 15, 2000
INVENTOR(S) : Hyoung-Joo Lee

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 5,
Line 8, change "program" to -- channel --.

Signed and Sealed this

Seventh Day of August, 2001

Attest:

Nicholas P. Godici

NICHOLAS P. GODICI

Attesting Officer

Acting Director of the United States Patent and Trademark Office

JS 44 (Rev. 12/07)

CIVIL COVER SHEET

The JS 44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. (SEE INSTRUCTIONS ON THE REVERSE OF THE FORM.)

I. (a) PLAINTIFFS

Samsung Electronics Co., Ltd.,

(b) County of Residence of First Listed Plaintiff ______
(EXCEPT IN U.S. PLAINTIFF CASES)

(c) Attorney's (Firm Name, Address, and Telephone Number)
Richard L. Horwitz (#2246)/David E. Moore (#3983)
Potter Anderson & Corroon LLP
1313 N. Market Street Wilmington, Delaware 19801 (302) 984-6000

DEFENDANTS

Pettters Group Worldwide LLC, Polaroid Corporation and Westinghouse Digital Electronics, LLC

County of Residence of First Listed Defendant ______
(IN U.S. PLAINTIFF CASES ONLY)

NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE LAND INVOLVED.

Attorneys (If Known)

II. BASIS OF JURISDICTION (Place an "X" in One Box Only)

- ☐ 1 U.S. Government Plaintiff
- ☑ 3 Federal Question (U.S. Government Not a Party)
- ☐ 2 U.S. Government Defendant
- ☐ 4 Diversity (Indicate Citizenship of Parties in Item III)

III. CITIZENSHIP OF PRINCIPAL PARTIES (Place an "X" in One Box for Plaintiff and One Box for Defendant) (For Diversity Cases Only)

	PTF	DEF		PTF	DEF
Citizen of This State	☐ 1	☐ 1	Incorporated *or* Principal Place of Business In This State	☐ 4	☐ 4
Citizen of Another State	☐ 2	☐ 2	Incorporated *and* Principal Place of Business In Another State	☐ 5	☐ 5
Citizen or Subject of a Foreign Country	☐ 3	☐ 3	Foreign Nation	☐ 6	☐ 6

IV. NATURE OF SUIT (Place an "X" in One Box Only)

CONTRACT
- ☐ 110 Insurance
- ☐ 120 Marine
- ☐ 130 Miller Act
- ☐ 140 Negotiable Instrument
- ☐ 150 Recovery of Overpayment & Enforcement of Judgment
- ☐ 151 Medicare Act
- ☐ 152 Recovery of Defaulted Student Loans (Excl. Veterans)
- ☐ 153 Recovery of Overpayment of Veteran's Benefits
- ☐ 160 Stockholders' Suits
- ☐ 190 Other Contract
- ☐ 195 Contract Product Liability
- ☐ 196 Franchise

REAL PROPERTY
- ☐ 210 Land Condemnation
- ☐ 220 Foreclosure
- ☐ 230 Rent Lease & Ejectment
- ☐ 240 Torts to Land
- ☐ 245 Tort Product Liability
- ☐ 290 All Other Real Property

TORTS

PERSONAL INJURY
- ☐ 310 Airplane
- ☐ 315 Airplane Product Liability
- ☐ 320 Assault, Libel & Slander
- ☐ 330 Federal Employers' Liability
- ☐ 340 Marine
- ☐ 345 Marine Product Liability
- ☐ 350 Motor Vehicle
- ☐ 355 Motor Vehicle Product Liability
- ☐ 360 Other Personal Injury

PERSONAL INJURY
- ☐ 362 Personal Injury - Med. Malpractice
- ☐ 365 Personal Injury - Product Liability
- ☐ 368 Asbestos Personal Injury Product Liability

PERSONAL PROPERTY
- ☐ 370 Other Fraud
- ☐ 371 Truth in Lending
- ☐ 380 Other Personal Property Damage
- ☐ 385 Property Damage Product Liability

CIVIL RIGHTS
- ☐ 441 Voting
- ☐ 442 Employment
- ☐ 443 Housing/ Accommodations
- ☐ 444 Welfare
- ☐ 445 Amer. w/Disabilities - Employment
- ☐ 446 Amer. w/Disabilities - Other
- ☐ 440 Other Civil Rights

PRISONER PETITIONS
- ☐ 510 Motions to Vacate Sentence

Habeas Corpus:
- ☐ 530 General
- ☐ 535 Death Penalty
- ☐ 540 Mandamus & Other
- ☐ 550 Civil Rights
- ☐ 555 Prison Condition

FORFEITURE/PENALTY
- ☐ 610 Agriculture
- ☐ 620 Other Food & Drug
- ☐ 625 Drug Related Seizure of Property 21 USC 881
- ☐ 630 Liquor Laws
- ☐ 640 R.R. & Truck
- ☐ 650 Airline Regs.
- ☐ 660 Occupational Safety/Health
- ☐ 690 Other

LABOR
- ☐ 710 Fair Labor Standards Act
- ☐ 720 Labor/Mgmt. Relations
- ☐ 730 Labor/Mgmt.Reporting & Disclosure Act
- ☐ 740 Railway Labor Act
- ☐ 790 Other Labor Litigation
- ☐ 791 Empl. Ret. Inc. Security Act

IMMIGRATION
- ☐ 462 Naturalization Application
- ☐ 463 Habeas Corpus - Alien Detainee
- ☐ 465 Other Immigration Actions

BANKRUPTCY
- ☐ 422 Appeal 28 USC 158
- ☐ 423 Withdrawal 28 USC 157

PROPERTY RIGHTS
- ☐ 820 Copyrights
- ☑ 830 Patent
- ☐ 840 Trademark

SOCIAL SECURITY
- ☐ 861 HIA (1395ff)
- ☐ 862 Black Lung (923)
- ☐ 863 DIWC/DIWW (405(g))
- ☐ 864 SSID Title XVI
- ☐ 865 RSI (405(g))

FEDERAL TAX SUITS
- ☐ 870 Taxes (U.S. Plaintiff or Defendant)
- ☐ 871 IRS—Third Party 26 USC 7609

OTHER STATUTES
- ☐ 400 State Reapportionment
- ☐ 410 Antitrust
- ☐ 430 Banks and Banking
- ☐ 450 Commerce
- ☐ 460 Deportation
- ☐ 470 Racketeer Influenced and Corrupt Organizations
- ☐ 480 Consumer Credit
- ☐ 490 Cable/Sat TV
- ☐ 810 Selective Service
- ☐ 850 Securities/Commodities/ Exchange
- ☐ 875 Customer Challenge 12 USC 3410
- ☐ 890 Other Statutory Actions
- ☐ 891 Agricultural Acts
- ☐ 892 Economic Stabilization Act
- ☐ 893 Environmental Matters
- ☐ 894 Energy Allocation Act
- ☐ 895 Freedom of Information Act
- ☐ 900Appeal of Fee Determination Under Equal Access to Justice
- ☐ 950 Constitutionality of State Statutes

V. ORIGIN (Place an "X" in One Box Only)

☑ 1 Original Proceeding ☐ 2 Removed from State Court ☐ 3 Remanded from Appellate Court ☐ 4 Reinstated or Reopened ☐ 5 Transferred from another district (specify) ☐ 6 Multidistrict Litigation ☐ 7 Appeal to District Judge from Magistrate Judgment

VI. CAUSE OF ACTION

Cite the U.S. Civil Statute under which you are filing (**Do not cite jurisdictional statutes unless diversity**):
35 U.S.C § 101 et seq.

Brief description of cause:
Patent infringement

VII. REQUESTED IN COMPLAINT:

☐ CHECK IF THIS IS A CLASS ACTION UNDER F.R.C.P. 23 — **DEMAND $** — CHECK YES only if demanded in complaint: **JURY DEMAND:** ☑ Yes ☐ No

VIII. RELATED CASE(S) IF ANY

(See instructions): JUDGE ______ DOCKET NUMBER ______

DATE
6/10/08

SIGNATURE OF ATTORNEY OF RECORD
Richard L. Horwitz

FOR OFFICE USE ONLY

RECEIPT # ______ AMOUNT ______ APPLYING IFP ______ JUDGE ______ MAG. JUDGE ______

JS 44 Reverse (Rev. 12/07)

INSTRUCTIONS FOR ATTORNEYS COMPLETING CIVIL COVER SHEET FORM JS 44

Authority For Civil Cover Sheet

The JS 44 civil cover sheet and the information contained herein neither replaces nor supplements the filings and service of pleading or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. Consequently, a civil cover sheet is submitted to the Clerk of Court for each civil complaint filed. The attorney filing a case should complete the form as follows:

I. **(a) Plaintiffs-Defendants.** Enter names (last, first, middle initial) of plaintiff and defendant. If the plaintiff or defendant is a government agency, use only the full name or standard abbreviations. If the plaintiff or defendant is an official within a government agency, identify first the agency and then the official, giving both name and title.

(b) County of Residence. For each civil case filed, except U.S. plaintiff cases, enter the name of the county where the first listed plaintiff resides at the time of filing. In U.S. plaintiff cases, enter the name of the county in which the first listed defendant resides at the time of filing. (NOTE: In land condemnation cases, the county of residence of the "defendant" is the location of the tract of land involved.)

(c) Attorneys. Enter the firm name, address, telephone number, and attorney of record. If there are several attorneys, list them on an attachment, noting in this section "(see attachment)".

II. **Jurisdiction.** The basis of jurisdiction is set forth under Rule 8(a), F.R.C.P., which requires that jurisdictions be shown in pleadings. Place an "X" in one of the boxes. If there is more than one basis of jurisdiction, precedence is given in the order shown below.

United States plaintiff. (1) Jurisdiction based on 28 U.S.C. 1345 and 1348. Suits by agencies and officers of the United States are included here.

United States defendant. (2) When the plaintiff is suing the United States, its officers or agencies, place an "X" in this box.

Federal question. (3) This refers to suits under 28 U.S.C. 1331, where jurisdiction arises under the Constitution of the United States, an amendment to the Constitution, an act of Congress or a treaty of the United States. In cases where the U.S. is a party, the U.S. plaintiff or defendant code takes precedence, and box 1 or 2 should be marked.

Diversity of citizenship. (4) This refers to suits under 28 U.S.C. 1332, where parties are citizens of different states. When Box 4 is checked, the citizenship of the different parties must be checked. (See Section III below; federal question actions take precedence over diversity cases.)

III. **Residence (citizenship) of Principal Parties.** This section of the JS 44 is to be completed if diversity of citizenship was indicated above. Mark this section for each principal party.

IV. **Nature of Suit.** Place an "X" in the appropriate box. If the nature of suit cannot be determined, be sure the cause of action, in Section VI below, is sufficient to enable the deputy clerk or the statistical clerks in the Administrative Office to determine the nature of suit. If the cause fits more than one nature of suit, select the most definitive.

V. **Origin.** Place an "X" in one of the seven boxes.

Original Proceedings. (1) Cases which originate in the United States district courts.

Removed from State Court. (2) Proceedings initiated in state courts may be removed to the district courts under Title 28 U.S.C., Section 1441. When the petition for removal is granted, check this box.

Remanded from Appellate Court. (3) Check this box for cases remanded to the district court for further action. Use the date of remand as the filing date.

Reinstated or Reopened. (4) Check this box for cases reinstated or reopened in the district court. Use the reopening date as the filing date.

Transferred from Another District. (5) For cases transferred under Title 28 U.S.C. Section 1404(a). Do not use this for within district transfers or multidistrict litigation transfers.

Multidistrict Litigation. (6) Check this box when a multidistrict case is transferred into the district under authority of Title 28 U.S.C. Section 1407. When this box is checked, do not check (5) above.

Appeal to District Judge from Magistrate Judgment. (7) Check this box for an appeal from a magistrate judge's decision.

VI. **Cause of Action.** Report the civil statute directly related to the cause of action and give a brief description of the cause. **Do not cite jurisdictional statutes unless diversity.** Example: U.S. Civil Statute: 47 USC 553
Brief Description: Unauthorized reception of cable service

VII. **Requested in Complaint.** Class Action. Place an "X" in this box if you are filing a class action under Rule 23, F.R.Cv.P.

Demand. In this space enter the dollar amount (in thousands of dollars) being demanded or indicate other demand such as a preliminary injunction.

Jury Demand. Check the appropriate box to indicate whether or not a jury is being demanded.

VIII. **Related Cases.** This section of the JS 44 is used to reference related pending cases if any. If there are related pending cases, insert the docket numbers and the corresponding judge names for such cases.

Date and Attorney Signature. Date and sign the civil cover sheet.

AO FORM 85 RECEIPT (REV. 9/04)

United States District Court for the District of Delaware

Civil Action No. ______________

ACKNOWLEDGMENT OF RECEIPT FOR AO FORM 85

NOTICE OF AVAILABILITY OF A UNITED STATES MAGISTRATE JUDGE TO EXERCISE JURISDICTION

I HEREBY ACKNOWLEDGE RECEIPT OF 4 COPIES OF AO FORM 85.

6/10/08
(Date forms issued)

x [signature]
(Signature of Party or their Representative)

x Matthew D. Gordon
(Printed name of Party or their Representative)

Note: Completed receipt will be filed in the Civil Action